THE DESCRIPTION and USE OF AN INSTRUMENT, Called the DOUBLE SCALE OF *PROPORTION*.

By which Instrument, all Questions in

Arithmetick, *Geometry*, *Trigonometry*, *Astronomy*, *Geography*, *Navigation*, *Fortification*, *Gunnery*, *Gaging Vessels*, *Dialling*,

May be most accurately and speedily performed, without the Assistance of either Pen or Compasses.

By *Seth Partridge*.

LONDON,
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TO

The Right Worshipfull, Sir RICHARD COMBE, Knight.

The Authour presents these, with his other best Services.

SIR,

T*He Transcendency of your Knowledge in all Noble and Learned Sciences, hath heightened my ambition presumptuously to affix on you this Dedication, and to this boldness its your Love and Favour that invites me, and prevents me too of all Apologies for my thus doing. For truly I should not so boldly have adventured to shroud this unworthy Piece under the wings of your worthy Patronage, were I not assured, that as in Judgment you are able to discern of it; so in your noble disposition willing favourably to accept it. The poor Widows two mites being the utmost of her ability, was accepted of by him, who was greater than the greatest of Mortals, far above the great gifts of the Rich, which*

imboldens me (without doubt of obtaining) humbly to deſire your Worſhip, to vouchſafe me both pardon for my preſumption, & acceptance of my little mite, which having obtained, I ſhall think my ſelf, and work, to have a ſufficient protection againſt all Cynical and ill-affected Detractors, a thing which all mens Works (how excellent ſoever) are ſubject unto, (much more mine) and therefore into the wide Ocean *I dare not commit my weak Veſſel, without ſome able* Pilot, *ſuch as your* Noble Self, *whoſe ſound Judgement and great* Learning *is ſo well known, that your* Name *prefixt before my* Book, *will be not only a defence againſt the carping of* Zoyliſts, *but alſo to beget a good affection in the* Readers. *Not to trouble your worſhip more with words, my hope is, that this my boldneſs will be imputed to a will, rather to do you ſervice, than otherwiſe, might your Worſhip be pleaſed thereof ſo to make conſtruction, I have attained my deſired end, who am,*

Your Worſhips

ever to ſerve you,

Seth Partridge.

To the Reader.

Friendly Readers,

YOu have here presented to your view those most Excellent Scales, *or* Lines *of* Numbers, Sines, *and* Tangents *doubled, by means of the moving whereof, the use of compasses is wholly avoided, and the Question resolved, by applying the Scales one to another. Some men (I know) have laid aside the using of the single Scales, because with an ordinary pair of Compasses on a large Scale, they could not work many examples they desired. But by these double Scales, how large soever, he shall never be troubled with any Compasses, nor the work never to out-run the Scale: And besides, upon the Instrument may be inserted any other Scales or* Lines, *as are for mensuration, or otherwise, such as each mans Calling & Occasions do most require, & so make the Instrument of general use.*

To plead for my Book, I *will not, the Subject whereon it treats, will do that better than* I *can; I am sure here is a good Subject, a good piece of Cloath, if the Garment be not marred in the making; if it be, the fault is in the botching Taylor, not*

in the stuffe. The Ingenious (I know) will wink at faults for they know themselves subject to them, and faults declare men to be but men. As for Curiosity in the method, here is none, nor was any intended, my dishes being drest, not as at a Feast, but as at an Ordinary, nor placed in so methodical an order as they might have been, I taking things not orderly, but at an adventure, and as it happened to come into mind: I *know my* Subject, *nor method, will please, all, yet* I *doubt not, but it will please some. What the Ignorant say of it,* I *care not, they are like the Fox, that despised the graps, because they grew so high he could not reach them. And what the spiteful speak of it,* I *pass not, they are like the filthy Fly, that seeks all over the body for a sore, and when it cannot find one, it makes one. It is the censure of the impartial, judicious & solid Judgment which* I *respect, to whom I will stand, and to which only I will submit, resting Servant to all such, while I am.*

Seth Partridge.

An Advertisement.

HEre might have been expected the Print of the Rule, but in regard of its sliding it could not be well demonstrated: wherefore I thought good to Advertise, that this Scale and all other Mathematical Instruments, are accurately made by Mr. Walter Hayes at the Cross-Daggers in More-Fields, next Door to the Popes-Head-Tavern, London: Where they may be furnished with Books to shew the use of them: As also with all sorts of Maps, Globes, Sea-Platts, and Mathematical Paper, Carpenters Rules, Post and Pocket Dials for any Latitude, at Reasonable Rates.

THE

Double Scale of Proportion.

The Deſcription and Uſe of an Inſtrument conſiſting of *Doubled Scales.*

Whereby all Concluſions Mathematical may be performed only by Application of Scales.

CHAP. I.

The Inſtrument deſcribed.

THe Inſtrument whereof I treat in this Book, I call the *Double Scale*, for that the Scales, or Lines thereupon, are doubled ; ſo & in ſuch manner, that by applying the one to the other, they will of themſelves reſolve any queſtion Mathematical, that may be done by the Pen, or by Tables of Sines, Tangents, and Logarithms. The Scales principally inſcribed thereupon, are thoſe moſt admi-

admirable Lines of Numbers, of Sines, and of Tangents, whose use hath been heretofore set forth, only to be wrought upon with a pair of Compasses, and no otherwise. But I have so contrived them double, upon an Instrument to move, or slide along one by the other, in such manner, that upon the same, without any assistance of Compasses, I can work all Conclusions Mathematical, that can be wrought by the single Lines, with the help of Compasses, both in *Arithmetick*, *Geemetry*, *Trigonometry*, *Astronomy*, *Geography*, *Navigation*, *Gaging of Vessels*, *Fortification*, *Gunnery*, *Dialling*. Yea, and the Usurer too, may hereby also compute the true interest of his money. In all which, I shall give you some examples for your instruction, in the use of my Double Scale.

The body, or matter whereof the Instrument is made, may be either of Brass, or of very good and well seasoned Box. It consisteth of three pieces, or Rulers, each one about half an inch in breadth, & about a quarter of an inch in thickness, more or less, as the Maker and User of them pleaseth; and for their length, they may be made to what length you will, either one foot, two foot, three foot, or more or less, for they are not limited to any length, only the longer they are, the larger and more will be the divisions of the Scales, and

and so consequently the more exact in operation. These three Rulers, or pieces of this *Scale*, are to be all of one even length and thickness and by the edges so evenly joynted, that they may justly slide alone close one by the other, having at each end a little plate of Brass, or Wood fitted to hold them close together, and so fastened to the two out-side pieces, that they may be kept steady, and the middle Ruler to slide to and fro between them.

The Lines, or Scales ingraven on this Instrument, are the ordinary lines of Numbers, of Sines, and of Tangents, only they are set on double, that is, once upon one Ruler, and once upon the other, upon one and the same joynt; as the line of Numbers is set both upon one of the out-side pieces, & and on the middle piece, that is, on both sides the joynt, and numbered on both, and so set to the very edges of both Rulers, that both lines being joyned together, may appear to be but as one line of Numbers, & this line of Numbers is (as it were) twice repeated, or doubled in the length of the Ruler, that is, beginning with 1 at one end of the Ruler, which I call the lower end, and continued to 1 or 10 at the middle, and from thence begin again, and continued to 10 or 100 at the upper end. Also upon the other side of the Rulers, upon the same joynt, is in like

like manner ſet a like line of Numbers, and this line of Numbers is fitteſt to be uſed with the line of Tangents,as that on the other ſide is with the lines of Sines,without any turning of the Inſtrument. But you may omit on the line of Numbers upon one ſide, only obſerving to turn the Inſtrument, when the work requireth to be done on ſeveral lines,as in the ſequel it will appear.

The Scales ; or Lines of Sines, are in like manner ſet on twice, that is,once upon the other edge of the middle piece, and alſo on the in ſide of the other out-ſide piece, and they are to be ſet on,upon both ſides the joynt,that they may appear as one line of Sines, being laid cloſe together, and numbers ſet to the Diviſions on both parts, and is in the lines of Numbers.

The lines of Tangents is ſet upon the other ſide of the Rulers, oppoſite to the lines of Sines upon the ſame joynt with them,and likewiſe ſo ſet upon both parts of the Inſtrument, that the parts being laid cloſe together,the line may appear to be both as one line of Tangents, and numbered on both parts to 45 at the upper end, againſt 90 on the lines of Sines, and from 45 back again to 89 at the lower end, as is uſually done in the lines of Tangents.

This Inſtrument having thoſe *Scales*, or (as it

it pleaſed their firſt Inventor to call them) *Lines*, thus ingraven or ſet on it, will work all concluſions, as may be wrought by Mr. *Gunters* Lines, or Mr. *Wingates*, by only applying the Lines one to another, without the uſe of Compaſſes, which muſt be always had and uſed with theirs; yet you may uſe Compaſſes with theſe Scales, if you pleaſe, and ſo try and examine your work by both ways, and when you have made ſuch trial, uſe which way you like beſt, and that (for ought I know) may be my Double Scales.

To ſhew the making of the *Scales* of *Numbers*, *Sines* and *Tangents*, is a thing altogether needleſs, the making of them being already ſo ſufficiently ſet forth by others, that for me to do it again, were but labour loſt, both to me in writing, and to the Reader in reading. And thoſe that are makers of Mathematical Inſtruments, do already well underſtand the making of them, and for a man to make one for his own uſe, is but vain, for that he may buy one at a cheaper rate than make it, I ſhall therefore proceed to the uſe: Wherein note, that for diſtinction of the ſides of the Scales, or Lines on the Rulers, I uſe the Terms of *Firſt* and *Second*, as being as proper for the purpoſe as any other could have been: For evermore, that ſide of any Line, whereon the firſt term in

in the rule of Proportion is taken, I call the firſt ſide; and the other ſide of the Line, whereon the ſecond term in the Rule is taken I call the ſecond ſide. And then for the third term in the Rule, it is always taken on the ſame ſide that the firſt term is taken on: & for the fourth term, which is the term ſought, it is evermore found on that ſame ſecond ſide, whereon the ſecond term is taken. As if the firſt term be taken on any Scale, upon the out ſideRuler, then the ſecond term is on the middle Ruler, and if the firſt term be taken on the middle Ruler, then the ſecond term is on the ſame Scale upon an out-ſide Ruler: And when the work is by ſeveral Lines, then the two out-ſideRulers both bear the name of *Firſt*, or *Second.*

Other Scales may be added to this Inſtrument, and ſet on the ſides and edges thereof, as a Scale of equal-parts, or a Line of inches, a Meridian-line, a Gage-line, a line of Chords, the lines of Board and Timber-meaſure, or any others, ſuch as your Calling and Occaſions have moſt uſe for.

CHAP.

CHAP. II.

The use and Application of the double Scale of Numbers upon the Instrument, in the principal Rules of Arithmetick.

PROBLEM. I.

Of Multiplication.

Two Numbers being given to be multiplyed together, to find their Product, by the double lines.

IN Multiplication the Analogie is this; As 1 is to one of the numbers given, to be multiplyed together: So is the other of them, to the Product.

Wherefore it may be said, As I is to the Multiplicator; So is the Multiplicand to the Product. Or,

As 1 is to the Multiplicand; So is the Multiplicator to the Product.

When two numbers are to be multiplied together, the greater of them is usually counted for Multiplicand, and the lesser for Multiplicator.

To multiply two numbers by the double lines, the manner of working is thus: Place 1 on the first side, to the Multiplicator on the second side: And then against the Multiplicand on the first side, is the Product on the second side.

Or else, place 1 on the first, to the Multiplicand on the second, and then right against the Multiplicator found on the first, is the Product on the second.

Example 1. Let 8 and 4 be two numbers given to be multiplied together, to find their Product, do thus: upon any one of the sides, look out 1. (This side whereon I take the 1, I call the first side) I set this 1 to 4 on the other side (which I call the second side,) and then right against 8 on the same first side, whereon I did take 1; is 32 on the second side, whereon the 4 was taken: This 32 is the Product of 8 multiplied by 4, the thing required.

Or otherwise thus.

Set 1 on the first, to 8 on the second, and then right against 4 on that first, is 23 on the second, as before.

Example 2. Let 25 be a Multiplicator, and 30 the Multiplicand, and the Product of them multiplied together, required.

Set 1 on the first, to 25 on the second, and then right against 30 on the first, is 750 on the second

ſecond. This 750 is the product of 30 multiplied by 25, the thing required. In like manner, If you ſet 1 to 30, then againſt 25 taken on the ſame ſide the 1 was, is 730 on the other ſide whereon the 30 is.

Example 3. Let 45 and 25 be two numbers given to be multiplied together, & their Product required. To reſolve this by the double lines, ſet 1 on the firſt, to 25 on the ſecond; and againſt the other number given 45 on the firſt, is 1125 on the ſecond. This 1125 is the Product of 45, multiplied by 25, which was deſired. Or,

Set 1 on the firſt, to 45 on the ſecond, and then right againſt 25 on the firſt, is 1125 on the ſecond, as before.

Example 4. Let $8\frac{75}{100}$ be given to be multiplied by $6\frac{45}{100}$ To perform this work, ſet 1 on the firſt, to $6\frac{45}{100}$ on the ſecond, and then againſt $8\frac{75}{100}$ found on the ſame ſide that the 1 is on, is $56\frac{43}{100}$ and ſomething more: therefore $56\frac{43}{100}$ is the Product of $8\frac{65}{100}$, multiplied by $6\frac{45}{100}$, the thing ſought.

Or thus, Set 1 or 10 at the upper end of the line on the firſt, to $8\frac{5}{100}$ on the ſecond, and then againſt $6\frac{45}{100}$ on the firſt, is $56\frac{43}{100}$ on the ſecond, as before. The like practice is to be obſerved in multiplying any other numbers.

Note, that in working by the double lines

it will be all one, whether you work from 1 at the beginning of the line upwards, or from 10, at the upper end of the lines downwards As if you set 10 at the upper end on the first, to 4 on the second, and then against 8 on that first, you shall have 32 on the second.

How to square any number, or to multiply a number by it self, as also to cube any number.

Set 1 on the first, to the number to be squared on the second, and then against that given number on the first, is its square on the second. As if 12 be a number to be squared, then set 1 on the first, to 12 on the second, and then against 12 on the same first, is 144 on the second. Therefore 144 is the square of 12. And then again, against 144 on the first, is 1728 on the second, which is the Cube of 12.

PROBLEM II.

Of Division.

Any number being given, to be divided by another number, to find the Quotient.

IN Division, the Analogie is thus:
As the Divisor, is to an Unite:
So is the Dividend, to the Quotient.
Wherefore the work by the double lines is, thus

thus; Look out the Diviſor on the firſt, and ſet it to 1 on the ſecond, & then right againſt the Dividend on the firſt, is the Quotient on the ſecond.

Example 1. Let 273 be a number given to be divided by 13. Look 13 the Diviſor on any one ſide, which we call the firſt ſide, and ſet it to 1 on the ſecond ſide. And then right againſt the Dividend 273 upon that firſt, is 21 on the ſecond. Wherefore 21 is the Quotient of 273 divided by 13, which was required.

Example 2. Again, if 1728 be given to be divided by 12, then ſet 12 the Diviſor on the firſt, to 1 on the ſecond; & when that is done you ſhall right againſt 1728 the Dividend on that firſt, ſet 144 on the ſecond, which 144 is the Quotient of 1728, divided by 12, and ſo of any other.

In Diviſion note this, that ſo many times as the Diviſor may be placed under the Dividend, ſo many places of figures ſhall be in the Quotient. As if 34785, be to be divided by 75, the Quotient ſhall conſiſt of three figures only, and no more; becauſe 75 can be placed only, three times under 34785: And under 1728 the Dividend given, the Diviſor 12 can three times be placed, & therefore three figures in the Quotient. And if you will divide 144 by 12, then ſet 12 on the firſt, to 1

on the ſecond;which done;againſt 144 on the firſt, you have 12 on the ſecond.

Example 3. Let 46 $\frac{75}{100}$ be given, to be divided by 8 $\frac{5}{10}$, and the quotient required. In this caſe, as in all other: Set the Diviſor 8 $\frac{5}{10}$ on the firſt, to 1 on the ſecond, and then againſt the Dividend 56 $\frac{75}{100}$ on that firſt, is 5 $\frac{5}{10}$ on the ſecond: therefore 5 $\frac{5}{10}$ is the quotient required, very ſpeedily and exactly found.

PROBLEM III.
Of Reduction of Fractions.

To reduce any vulgar Fraction into a decimal Fraction.

LEt $\frac{65}{84}$ be a vulgar Fraction propounded, to be reduced into a decimal Fraction. Now it is to be noted, that vulgar Fractions are reduced into decimals by the rule of proportion, in this manner:

As the Denominator of the Fraction given,
Is to the Numerator thereof:
So is an Unite with cyphers, one, two, or three.
To a new Numerator, which Numerator will have ſo many places of figures in it, as the new Denominator hath cyphers, and therefore the Fraction given is thus reduced into a Decimal.

As

As the Denominator 84; Is to the Numerator 63.

So an Unite with two cyphers, thus 100, to 75, which 75 is the new Numerator to that new Denominator 100. Therefore $\frac{75}{100}$ is a decimall Fraction, equal in value to $\frac{63}{84}$. To work this kind of reduction by the double lines, do thus.

Set 84 (the Denominator of the vulgar fraction given) on the first, to 1 on the second & then right against 63, the Numerator on the first, is 75 on the second, which 75 is the new Numerator of a decimal Fraction, whose Denominator is an Unite with two cyphers. Thus is $\frac{63}{84}$ changed into $\frac{75}{100}$, which new Fraction is equal in value with the former.

Again, if 8 $\frac{12}{40}$ be a number given to be reduced into a decimal; set 40, the Denominator of the fractional part, to 1, and then right against 12, on that part as you took the 40, is 2 on that second side whereon the one was, and so the Fraction is become $\frac{3}{10}$, which joyned to the 8, makes the mixt number that before was 8 $\frac{12}{40}$, to be 8 $\frac{3}{10}$, and of equal value.

Note that the point 1 representeth also 10, 100, or 1000, and therefore the new Denominator may be taken either, 10, or 100, or 1000, as in your own judgement it shall seem most fitting. As here in this last Example, we

found 3 to ſtand right againſt 12, and therefore we put but one cypher to the unite, and made the Fraction $\frac{3}{10}$. And in the laſt Example before, we found 75 to be againſt the 63, which becauſe it conſiſteth of two places of Figures, we put two cyphers to the unite for Denominator of the new Fraction, and ſo made it $\frac{75}{100}$, and ſo of all other.

Alſo be it remembred, throughout the reſidue of this work, that all Fraction figures are ſet right in the line, like whole numbers, without any Denominator under them, being ſeparated or diſtinguiſhed from the whole part of that number by a Comma, as all ſuch Fractions as theſe 46 $\frac{75}{100}$, 6$\frac{45}{100}$, 8$\frac{5}{10}$, and 5 $\frac{5}{10}$, are thus expreſſed 46, 75. 6,45.8,5. and 5,5. which manner of writing Fractions being well obſerved, is a readier way than that other, of one number above, and another below, with a line between. Alſo note, That the Fractions ſo expreſſed are all Decimal Fractions whoſe Denominator is a Unite with ſo many Cyphers as there be Fraction figures, as the Denominator of the Fraction Figures of the 75 belonging to the whole number 46 is 100, being a unite with two cyphers, becauſe two figures and the Denominator to 5 is 10, being a unite with one cypher, becauſe but one figure. And when a Fraction is to be expreſſed alone without a

whole

whole number, then the Numerator is first expressed, and after it the Denominator right on in the line, with a Comma betwixt, as $\frac{75}{100}$, and $\frac{5}{10}$, are thus expressed 75, 100. 5, 10. and so of other the like.

PROBLEM. IV.

Of Continual Proportionals.

Two numbers being given; to find a third, a fourth, a fifth (or many numbers) in continual proportion Geometrical to them two.

Example. LEt the two numbers given be 2 and 4, and it be required to find several number in continual Geometrical proportion to them two.

Set 2 on the first, to 4 on the second, and then against 4 on that first, is 8 on the second, which is the third number in continual proportion Geometrical to them two; and then against 8 on the first, is 16 on the second, which 16 is the fourth number in continual proportion to them two; and against 16 on the first, is 32 on the second, the fifth continual proportional; and against 32 on the first, is 64 on the second, the sixth continual proportional; and against 64 on the first, is 128 on the second, the seventh continual proportional; and against

againſt 128 on the firſt, is 256 on the ſecond which is the eighth proportional to the two propoſed numbers. Wherefore 8, 16, 32, 64, 128,and 256, are a rank of numbers in continual Geometrical proportion ,to 2,and 4,the thing that was required.

Example 2.Let it be required to find a rank of numbers in continual proportion,as 2 to 3. Here ſet 2 on the firſt to 3 on the ſecond,and then without moving the Inſtrument, againſt 3 on the firſt,you have 4,5 on the ſecond,and againſt the ſame 4,5,found on the firſt,is 6,75 on the ſecond ; and againſt 6,75 on the firſt, is 10, 125 on the ſecond. Therefore 4, 5, 6, 75, and 10, 12 5, are a rank of numbers in continual proportion to 2 & 3, as is required.

If it be required,to find ſuch a rank of proportionals to the numbers 2 and 4,which may bear the ſame proportion to one another,as 2 bears to 4 : Set 4 to 2, and then againſt 2 on that firſt ſide whereon the 4 is, you have 1 on the ſecond ſide,which is the third proportional to 4 and 2,bearing the ſame proportion to 2, as 2 doth to 4. And againſt 1 on the firſt, is 5,10 on the ſecond, the fourth proportional ; and againſt 5,10 on the firſt, is 25,100 on the ſecond,which is the fift h number in continual proportion inverſe, or backward.

If the two numbers given be 10 and 9,and a rank

rank of Numbers to them in an inverſe proportion Geometrical be required ; ſet 10 on the firſt, to 9 on the ſecond, and then againſt 9 on the firſt, is 8,1 on the ſecond, which is the third proportional ; and then againſt 8, 1 is 7,29 the fourth proportional : whereof 10, 9 8,1 and 7,29 are numbers in a continual proportion. But if the numbers given be 1 and 9, and a third and fourth numbers in proportion to them, as 9 is to 1, be required, then muſt the numbers found be accounted 81 & 729, they being the third and fourth numbers in a Geometrical proportion to 1 and 9. In like manner, if the two numbers given be 10 and 12, then if you ſet 10 to 12, you ſhall ſee on the firſt againſt 12, 14, 4; which is the third proportional: and againſt 14, 4 one the firſt, is 17,28 on the ſecond, which is the fourth proportional, But had the two numbers given been 1 and 12, then bring 1 on the firſt, to 12 on the ſecond, & you ſhall have againſt 12 on the firſt, 144 on the ſecond, for the third proportional, and the forth will be 1728, and ſo of all other.

PROBLEM.

PROBLEM V.
Of the Rule of Proportion direct.

Three numbers being given, to find a fourth, the Analogie standeth thus.

AS the first numbers is to the second, So is the third number, to a fourth.

Therefore work thus: Set the first number in the proportion on the first side, to the second number in the proportion on the second side: And then against the third number on the first, is the fourth nnmber sought for on the second.

Example 1. Let the Diameter of a known circle be 7, and its circumference 22, & it be required to know what the circumference of another circle is, whose Diameter is 14. To resolve this *quære*: Set 7 on the first to 22 on the second, and then against 14, the Diameter of the other circle found on the first, is 44 on the second: This 44 is the circumference of that other circle, whose Diameter is 14.

Example 2, If 45 yards of Stuff cost 30, pound, what will 84 yards of it cost?

Set 45 (the first number in the Rule) on the first

firſt to 30(the ſecond number)on the ſecond; and then againſt 84 (the third number in the Rule) on the firſt, is 56 on the ſecond,which 56 is the fourth number,and ſheweth that 84 yards will coſt 56 punds. Or.

If 45 acres of land be worth 30 pounds a year,what will 84 acres be worth by the year. The anſwer is as before 56 pounds.

And if 26 of any thing give, 64,what will 36 of the ſame give ? Set 26, to 64,and then againſt 36 on the firſt,is 88,615 the anſwer to the queſtion demanded on the ſecond.

Note, that generally in the Rule of direct proportion ; If the third number be greater than the firſt,then will the fourth number be greater than the ſecond.But if the third number be leſs than the firſt, then the fourth number will be leſs than the ſecond.

Example 3. If the circumference of a circle be 22, and its Diameter 7, what will the Diameter of another circle, whoſe circumference is 44 ?

Here ſet 22 on the firſt,to 7 on the ſecond, & then againſt 44 one the firſt,is 14 on the ſecond, which 14 is the Diameter of that circle,whoſe circumference is 44, by their meaſures taken in inches,feet, or any other meaſure whatſoever.

To make proof of the work,whether truly wrought,

wrought, or not. Multiply the first term in the Rule, and the fourth term newly found, the one by the other, and likewise the second and third terms; and if the two Products be equal, the work is truly wrought, or else not.

To prove the last question by the lines; Set 1 on the first, to 22 on the second, and then against 14 on the first, is 308 on the second: Next, set 1 to 7, and then against 44 on that first, is 308 on the second, here both Products being equal, proves the work to be truly wrought.

PROBLEM VI.
The Rule of Proportion Inverse.

Three numbers being given, to find a fourth in an Inversed Proportion.

IT is to be noted, in this Inverse Rule of Proportion, that if the third number be greater than the first, then will the fourth number be less than the secoud. And contrariwise, if the third number be less than the first, then the fourth number is to be greater than the second.

But in the Rule of Proportion direct; If the second number, or term, be more than the first,

firſt, then the fourth term is alſo more than the third. And if the ſecond term be leſſe than the firſt,then is the fourth term leſs than the third.

This Inverſe Rule may be wrought two wayes on our double lines. One way is thus:

Set the firſt term, on the firſt, to the other term of the ſame denomination on the ſecond: And then againſt the other term of contrary denomination, ſought out on that ſecond,is the fourth number ſought for,on the firſt; Or elſe,ſet the third term on the firſt,to the firſt term on the ſecond, and then againſt the ſecond term on the firſt, is the anſwer on the ſecond.

Example 1.If 60 Pioners can make a trench in 45 hours;In how long time can 40 Pioners make it?

Set 40 on the firſt,to 60 on the ſecond (the two numbers of the ſame denomination:) and then againſt 45 on that firſt (the number of contrary denomination) is 67,5 on the ſecond, which 67, 5 is the fourth term in reciprocal proportion to the other three, and of the ſame denomination with 45, *viz.* hours, and is the anſwer to the queſtion demanded, ſhewing that 40 men can do as much in 67, 5 hours, as 60 men can do in 45 hours. Or ſet 68 on the firſt, to 40 on the ſecond, and then againſt

againſt 45 on that ſecond, is 67,5 on the firſt.

Another way is thus: Set 40 the third term, on the firſt, to 45 on the ſecond, (which is the term of contrary denomination to the other two) and then right againſt 60, on the firſt, (which is the number of the ſame denomination with the 40) is 67,5 on the ſecond, the number ſought. Thus one way of working proves the other.

Example 2. If 45 men do a work in 30 dayes: In how many dayes will 270 men do it?

Set 270 on the firſt, to 45 on the ſecond, and then againſt 30 on the firſt, is 5 on the ſecond. Or,

Set 270 on the firſt, to 30 on the ſecond, and then againſt 45 on the firſt, is 5 on the ſecond: And therefore the fourth number ſought for is 5, ſhewing that 270 men will do as much work in 5 dayes, as 45 men can do in 30 dayes.

This Rule is proved by multiplying together the firſt and ſecond terms, and alſo the third and fourth: And if the two Products be equal, the work is truly wrought, or elſe not.

By the lines it is thus proved: Set I on the firſt, to 30 on the ſecond, and then againſt 45 on the firſt, is 1350 on the ſecond. This done Set 1 on the firſt, to 5 on the ſecond, and then

againſt

againſt 270 on the firſt, is 1650 on the ſecond here both Products being equal, declareth the work to be truly wrought.

PROBLEM VII.
Of Duplicated Proportion.

Three numbers being given, to find the fourth in a Duplicate Proportion.

THis Rule chiefly concerns the proportion of Lines to Superficies; or of Superficies to Lines.

1 *Of the Proportion of Lines to Superficies.*

Example 1. If the diameter of a circle be 14 inches, and its Content 154 inches; What will the Content be of another circle, that is 28 inches in diameter?

Set 14 on the firſt, to 28 on the ſecond, (they being the terms of one denomination, *viz.* Lines) and then againſt 154 on the firſt, (the content of the circle given is 308 on the ſecond: This 308 ſeek on the firſt, and againſt it on the ſecond is 616, which 616 is the content of that other circle of 28 inches diameter

Example 2. Let the diameter of one circle be 7 foot, and the Area of it 38,5 foot, and let it be demanded, What the ſuperficial Area of another circle is, whoſe diameter is 18 foot.

Becauſe 7 and 18 be terms of one denomination, *viz.* Lines; Set 7, (the diameter of the the circle, whoſe Content is known) on the firſt, to 18 on the ſecond, being the diameter of the other circle, whoſe Content is ſought, and then againſt 38, 5 (the Content known) on the firſt, is 99 on the ſecond, and then ſeek this 99 on the firſt, and againſt it is 254, 5 tenths on the ſecond, which is the ſuperficial Area, or Content in feet of that other circle which was demanded.

Example 3. If a peece of land that is 20 pole ſquare be worth 30 pounds; What is a peece of land of the ſame goodneſs worth, that is 35 pole ſquare?

Set 20 on the firſt, to 35 on the ſecond, and then againſt 30 on the firſt, is 52, 5 on the ſecond; and laſtly, againſt 52,5 on the firſt, is 91,8 on the ſecond: that is 91 pounds, and eight tenths of a pound, or 16 ſhillings. So much is the worth of that piece of land of 35 pole ſquare.

Example 4. How many acres of land of our Engliſh meaſure of 16, 5 foot to the people, are contained in 30 Iriſh acres, of 21 foot to the pole.

Place 16,5 on the firſt to 21 on the ſecond and then againſt 30 on the firſt, is 38,2 on the ſecond; and againſt 38, 2 on the firſt, is 48, 6 on

on the ſecond. So many Engliſh acres are in 30 Iriſh acres.

2 *Of the Proportion of Snperficies to Lines.*

If the two terms of like denomination be of ſuperficial Contents, and a diameter, or a line ſought for.

Example. Let two circles be given, the Content of the one being 154, and its diameter 14. the Area of the other circle is 616 and its diameter is required.

Set the Area of the circle known, *viz.* 154 on the firſt, to its diameter 14 on the ſeeond and then againſt 616 on the firſt, is 56 on the ſecond. The half whereof, *viz.* 28, is the diameter of that other circle, whoſe Content is 616, which 28 is feet, or inches, or any other meaſure, ſuch as the diameter of the other circle was meaſured by.

PROBLEM VIII.
Of Triplicate Proportion.

Three numbers being given, to find a fourth, in a Triplicated Proportion.

THis Rule concerneth the proportion betwixt Lines and Solids. *Example* 1. There is a Bullet whoſe diameter is 4 inches, weigheth 9 pounds: What will another Bullet

weigh, whose diameter is 8 inches,and of the same metal.

Set 4 on the first, to 8 on the second, (that is the one diameter to the other:) And then against 9 on the first, (which is the weight of the Bullet of 4 inches diameter) is 18 on the second; and against 18 on the first, is 36 on the second; and thirdly, against 36 on the first,is 72 on the second, This third sum found, is the fourth proportional number, which was required,shewing that the weight of that other Bullet of 8 inches diameter,is 72 pounds.

Example 2. If a Gun of 5 inches diameter, require for her due charge 16 pound of powder; How much powder will a Gun of 4 inches diameter in the bore require,for her due charge,of the same powder?

Place 5 on the first, to 4 on the second,and then against 16 on that first, is 12,8 on the second; and next against 12, 8 on the first, is 10, 24 on the second;and thirdly,against that 10,24 on the first, is 8,2 on the second,which third number 8, 2 is the answer to the question: shewing that 8 pounds, and 2 tenth parts of a pound of powder, is a due charge for a Gun of 4 inches bore.

PRO-

PROBLEM IX.

A Company of men laying down ſeveral ſums of money together into one ſtock, wherewith they trade and get gain; to find out how much each mans part of the gain muſt be, anſwerable to his part of mony laid down in ſtock.

LEt 5 men, whoſe names let be repreſented by theſe five letters, A, B, C, D, E, make a ſtock of 300 pounds, of which ſtock A put in 84 pounds, B put in 72 pounds, C put in 48 pounds, D put in 54 pounds and E put in 42 pound, which all together make the 300 pounds. Now at the end of a time, having traded therewith, they gained clearly 50 pounds: And let it be demanded, what portion of the gain each man muſt have, according to his proportion of mony laid down in ſtock.

The Rule to anſwer this demand is thus.

As 300, the whole ſtock, To 50 pounds the whole gain;

So is each mans portion of the ſtock, To his portion of the gain.

Therefore,

Set 300, the ſtock on the firſt, to 50 the gain on the ſecond; & then againſt each mans particular portion laid down, being ſought out on the firſt, is his portion of the gain on the

ſecond. As againſt 84, the portion laid down by A on the firſt, is 14, his portion of the gain on the ſecond; and againſt 72, the portion of B, is 12 pounds, his portion of the gain; againſt 48. the portion of C. is 8 pounds his portion of the gain; againſt 54, the portion of D, is 9, his portion of the gain; and againſt 42 pounds on the firſt, the portion of E, is 7 pounds on the ſecond, his portion of the 50 pounds gain, Thus much is each mans ſeveral portion of the 50 pounds gain; all which ſeveral portions of the gain added together, make up the whole gain of 50 pounds.

Thus upon our lines can we work that rule of Arithmetick, called *The Rule of Fellowſhip*; which is, when diverſe men adventure a ſtock of money together, and therewith trade, and either gain or loſe a certain ſum of money, to find each mans portion of the gain or loſs, anſwerable to his portion of money put into the ſtock.

PROBLEM X.

Of Intereſt and Annuities.

To find the Intereſt of any ſum of money, after any rate by the 100 *propounded.*

WHat is the Intereſt of 65 pounds for a year, after the rate of 8 in the 100?

By

By the rule of Proportion, the queſtion is thus reſolved :

As 100, is to 108 ; So is 65, to the fourth term.

Set 1 or 100 on the firſt, to 108 on the ſecond, and then againſt 65 on the firſt, is 70, 2 on the ſecond, which is 70 pounds 4 ſhillings; ſo much doth the principal and intereſt ariſe unto in a year, that is to ſay, five pounds and four ſhillings : And without ſtirring the Inſtruments againſt any other ſum of Principal on the firſt, is the Principal & Intereſt thereof on the ſecond. As againſt 40 pounds, is 43 pounds 4 ſhillings; and againſt 80 pounds, is 86 pounds and 8 ſhillings. From whence it appeareth, that 3 pounds 4 ſhillings is the Intereſt of 40 pounds for a year; and 6 pounds 8 ſhillings, the Intereſt of 80 pounds for a year. In like manner, againſt 27 pounds 14 ſhillings Principal, or 27, 7 is 29 pounds 18 ſhillings, and a little more.

Or elſe work thus.

Set 1 or 100 back to 8, and then againſt 65 on that firſt, is 5, 2 on the ſecond; and againſt 40 pounds on the firſt, is 3, 2 on the ſecond : So the Intereſt of the one is 5 pounds 4 ſhillings, and of the other 3 pounds 4 ſhillings.

If the rate of the Intereſt propoſed be 6 in the 100, then ſet 100 on the firſt, to 106 on the

ſecond; and then againſt 65 pounds on the firſt, is 68 pounds 18 ſhillings on the ſecond, which is the Principal and Intereſt together of 65 pounds for a year. Or,

Set 100 on the firſt, to 6 on the ſecond, and then againſt 65 on the firſt, is 3, 9 on the ſecond this 3,9 is 3 pounds 18 ſhillings, the Intereſt alone of 65 pounds for a year, and ſo of any other.

Of Intereſt of money continued from year to year.

The increaſe or Intereſt of money from year to year for many years, is in continual proportion to the Principal, as 100 is to its Intereſt; as if 40 pounds were to be continued at Intereſt for many years, at the rate of 6 in the 100'

Set 100 on the firſt, to 106 on the ſecond, and then againſt 40 on the firſt, is 42,4 on the ſecond, that is 42 pounds 8 ſhillings, ſo much is the firſt years Principal and Intereſt. And now, if you look 42, 4 on the firſt, you ſhall have right againſt it 44,9 and more, that is 44 pounds 18 ſhillings and more, for the Principal and Intereſt of two years; & againſt, 44,9 on the firſt, is 47.6 and better, on the ſecond, that is 47 pounds 12 ſhillings 8 pence, the Intereſt and Principal of 40 pounds in three years. Again, againſt 47,6 on the firſt, is 50, 45 and

and better, that is 50 pound 9 ſhillings 7 pence; So much is the Principal and Intereſt, together of 40 pounds at the end of 4 years, and ſo forth to as many years as is required.

Of Annuities,

When lands are ſold at certain years purchaſe, according to the yearly rent, to find what their value upon the purchaſe will be: Set 1 on the firſt, to the number of years purchaſe on the ſecond; and then againſt their yearly rent on the firſt, is the value of the purchaſe on the ſecond.

Example. Let a houſe and land worth 16 pounds a year, be ſet to ſale at 14 years purchaſe, and demand made how much money it will ariſe unto at that rate.

Set 1 on the firſt, to 14, the number of years purchaſe on the ſecond; and then againſt 16, the yearly rent on the firſt, is 224 on the ſecond which is 224 pounds: So much money doth the purchaſe ariſe unto, of 16 pounds a year bought at 14 years purchaſe.

If the price of the lands be given, and that it coſt after 14 years purchaſe, to find what yearly rent is was ſold at. In this caſe, Set 14 on the firſt, to 1 on the ſecond; and then againſt the ſum of money paid 224 pounds, is 16, which is 16 pounds: So much is the yearly rent ſought.

A man

A man borrowed 666 pounds 13 ſhillings and 4 pence for 12 years,& covenanted that he would repay at the 12 years end 1333 pounds 6 ſhillings and 8 pence.It is deſired to know after what rate of Intereſt by the 100, he paid for his money borrowed.

Set 1333 $\frac{1}{3}$ on the firſt, the ſum of money to be paid, to 666² on the ſecond (the ſum lent) and then againſt 12 on the ſecond (the term of years it was lent) is 5, 95, which is 5 pounds 19 ſhillings:So much by the 100 doth he pay for the money lent.

A Sum of money being due at a certain time to come, to find what it is worth in preſent money to take in.

There is 402 po ds 2 ſhillings due at the end of 5 years to come,I would know what it is worth in ready money, abating Intereſt for the money received in, before due, after the rate of 8 in the 100.

Firſt, ſet 108 on the firſt,to 100 on the ſecond, and then againſt 402, 1 on the firſt, is 37,1 on the ſecond. Secondly, againſt 37, 1 on the firſt, is 34,46 on the ſecond. Thirdly, againſt 34,46 on the firſt, is 31, 95 on the ſecond. Fourthly, againſt 31, 95 on the firſt, is 29, 71 on the ſecond. Fifthly, againſt 29, 71 on the firſt, is 373 on the ſecond. So much namely

namely, 373 pounds may be received in present money for the 402 pounds and 2 shillings due 5 years hence, as being the present worth thereof.

Here take notice, that as the Principal and Interest of money forborn for many years, increaseth in a proportion direct; So in this case, where money is paid many years before due, it decreaseth in the like proportion.

CHAP. III.

The use of the double Scale of Numbers in Superficial measure, as Board, Glass, Land, and the like.

PROBLEM. I.

The length and breadth of any square, or long square Superficies being given, to find the Content thereof.

If the length and breadth be given in inches, Then,

As 1 to the breadth in Inches, So is the length in Inches, To the Content in Inches.

Example. Let a plain Superficies, as a Board or Plank be given to be measured, the breadth

is

is found 30 Inches,and its length 183,and the Content required.

Set 1 on the first, to 30 on the second,and then against 183 on the first,is 5490,the Content sought in Inches.

If the Superficies given, be a piece of land, 30 perches broad, and 183 long,the Content is 5490 perches.

Again, let a piece of Wainscot be 2,5 foot in breadth,and 15,25 foot in length,the Content will be found 38,12 foot. For,

Set 1 on the first,to 2,15 on the second,and then against 15,25 on the first, is 38,12 foot, the Content sought.

PROBLEM II.

The breadth and length of any Superficies being given in one kind of measure,to find the Content in another kind of measure.

LEt the length and breadth be given in Inches,and the Content required in feet.

The Rule is thus:

As 144 to the breadth in inches, So is the length in inches, To the Content in feet.

Example. Let the breadth be 30 inches,and the length 183 inches,and the Content in feet required.

In this case,because 144 inches make a foot of superficial measure, Set 144 on the first,

to

to 30 the breadth on the ſecond, and then againſt 183, the length on that firſt, is 38 foot, and a Fraction of a foot, being a little more than one tenth part of a foot: So many foot are in that Board, or what other platform it be, that is given to be ſo meaſured.

If the platform were a piece of land 30 perches broad, and 183 perches long, then the Analogie is thus: As 160, (the perches making an acre) to the breadth in perches; So is the length in perches, To the Content in acres.

And therefore in this caſe of land meaſure, Set 160 on the firſt, to 30 the breadth on the ſecond; and then againſt 183, the length on that firſt, is 34,31 on the ſecond: So many acres of land are contained in that ground.

If the place, whoſe Content is to be caſt up, be a Triangle, a Trapezia, or of any other form whatſoever, the Analogie in general is this;

As 144, or 160, &c. is to one of the numbers given to be multiplyed together; So is the other of them, to the Content in Feet or Acres, &c.

There is a piece of Wainſcot, that is 3, 5 foot broad, and 21 foot long: How many yards is in it?

Seing that in a yard are contained 9 foot; Therefore, Set 9 on the firſt, to 3,5 on the ſecond,

ſecond; and then againſt 21 on the firſt, is 8,16 on the ſecond: So many yards is in that piece.

PROBLEM III.

The breadth of a Superficies being given in one kind of meaſure, and the length in another, to find the Content in the greater meaſure.

LEt the breadth of a Superficies given be in inches, and the length in feet, and the Content in feet required:

Here the Analogie is:

As 12 to the breadth in inches; So the length in feet, to the Content in feet:

So that if the breadth be 30 inches, and the length 15,25 foot, the Content, will be, 38, 12 foot: For.

Set 12 on the firſt, to 30 on the ſecond; and then againſt 15,25 on the firſt, is 38,12 on the ſecond, being the Content ſought for: Or elſe, Set 12 to 15,25, and then againſt 30 on that firſt, is 38, 12 on the ſecond.

By this rule alſo: If the breadth of a plot of land be given in perches, and the length in chains (being meaſured by a chain of 4 perches long) the Content in Acres is readily had.

Example. Let a piece of land be in breadth 30 perches, and in length 15,25 chains, meaſured by a chain of 4 perches in length.

In this caſe the Analogie is thus:

As

As 4 is to the breadth in poles, So is the length in chains to the Content in Acres. Therefore, ſet 4 to 30, and then againſt 15,25 on that firſt ſide whereon the 4 is, you ſhall have 11,4 on the ſecond ſide: So much is the Content in Acres of that piece of land.

Again, let a peice of land be 36 poles broad, and the length 23 chains and an half; to find the Content.

Set 4 on the firſt, to 36 on the ſecond, and then againſt 23,5 on that firſt, is 21,1 and better on the ſecond: the Content ſought.

PROBLEM. IV.

The length and breadth of a Superficies being given in feet, to find the Content in yards.

TAke this for a general Rule: As 9 is to the breadth in feet; So is the length in feet, To the Content in yards.

Example. Let the breadth of a pane of Wainſcot be 4 foot, and the length 12 foot, and the Content in yards be ſought for,

Here is no more to be done, but to ſet 9 on the firſt, to 4 on the ſecond; and then againſt 12 on the firſt, is 5, 35 on the ſecond: The Content in yards of that pane, which is almoſt 5 yards, a quarter and an half, or rather 5 yards and one third part of a yard.

PRO-

PROBLEM. V.

The breadth of any Superficies being given in inches or feet, to find how much in length will make a superficial foot.

The Rule is thus.

AS the breadth in inches, to 144; So is 1 to the length in inches, to make a foot.

Example. Let the breadth given be 30 inches, and the length to make a foot at that breadth be required.

Set 30 on the first, to 144 on the second, and then against 1 on the first, is 4,8 on the second: So much in length makes a foot at 30 inches broad.

But if the breadth be given in feet; Then,

As the breadth in feet is to 1, So is 1 to the length to make a foot: Therefore,

Set 2, 5 on the first, to 1 on the second, and then against 1 on the first side, is 4 on the second, which 4 signifieth four tenth parts of a foot: So much in length makes a foot at that breadth.

PROBLEM VI.

The length and breadth of a plot of land being given in chains, to find the Content in Acres.

HAving a chain of 4 perches long, divided in 100 links, that is, 25 in the perch; meaſure the length and breadth of the land to be meaſured in chains and links: And then caſt up the Content in Acres thus:

As 10 to the breadth in chains;
So is the length in chains, to the Content in Acres.

Example, Let the breadth given be 7 chains 50 links, and the length 45 chains, 75 links, and the content in Acres ſought:

Set 10 on the firſt, to 7,5 on the ſecond, and then againſt 45,75 on the firſt, is 34,31 on the ſecond, which is the Content in Acres of that plot of land. Or.

Had the breadth been 15 chains, 25 links, & the breadth 22 chains, 50 links; then ſet 10 or 1 on the firſt, to 15, 5 on the ſecond, and then againſt 22,50 on the firſt, is 34, 31 on the ſecond, the Content in Acres ſought for: which Fraction 31 above the 34 Acres, contains 1 rood 10 perches. So that the Content is 34 Acres, 1 rood and 10 pole.

If the plot of land be of a Triangle form, or

any other figure whatſoever, the Analogie is this:

As 10 is to one of the two numbers of chains, that are to be multiplyed together: So is the other of them, to the Content in Acres.

As if the half perpendicular of a Triangle be 3,75 chains, and the Baſe 45,75, the Content will be found to be 17,15 Acres.

For ſet 10 on the firſt, to 3,75, on the ſecond, and then againſt 45,75 on that firſt, is 17,15, the content.

Or elſe, having the whole Baſe, and whole perpendicular, ſay thus: As 20 to the whole perpendicular 7, 50; So is the whole Baſe 45,75; To 17,15 the content in Acres, as before: For,

Set 20 on the firſt, to 7, 50 on the ſecond, and then againſt 45,75 on the firſt, is 17,15 on the ſecond.

Or if the Baſe of a Triangle be 36,83 chains and the perpendicular 17,59 chains, the content will be found by either way of working, to be 32,39, which is 32 acres, 1 rood 22 perches.

PRO-

PROBLEM VII.

The Content of a piece of Land being measured by one kind of perch, to find the Content thereof after another kind of perch.

THese kind of proportions are wrought by the Rule of Three reverse, after a duplicated proportion; and the Analogie is thus:

As the length of the second perch,
is to the length of the first perch:
So the content in acres given,
to a fourth number: and so is that fourth number to a fifth number, which is the content sought.

Suppose a piece of land measured by the 16 ½ foot-pole, do contain 34, 3 acres, and it be demanded; How much it would contain, if it were measured by an 18 foot-pole.

Note that I call the 16 ½ foot-perch, the first perch, because by it the land was measured; and the 18 foot-perch I call the second perch, because according to it the content is sought for. Wherefore.

Set the second perch 18 on the first, to 16,5 on the second, (the perch first used) and then against 34,3, the content in acres given, on the first, is 31,45 on the second; and then against that 31,45 on that first, is 28,8 on the second:

So much is the content in acres by the 18 foot-pole, which was demanded.

In like manner where the Content given 5 acres, 2 roods, 20 pole, or 5,62: Set 18 on the first, to 16, 5 on the second, and then against 5,62 on the first, is 5,15 on the second. And lastly, against that 5, 15 on that first, is near about 4,7 on the second: So much is the content of that close by the, 18 foot pole.

PROBLEM. VIII.

The one side of any piece of Land being given, to find how much in breadth the other way will make an Acre of Land.

LEt the side of a close be 20 pole, and it be required; How much in breadth will make one acre of land at that length.

Set the breadth given, 20 on the first, to 160 on the second; and then against 1 or 10 on that first, is 8 on the second. So much in breadth makes an acre at 20 pole long.

Or if the side measured be 25, then set 25 to 160, and against 1 on that first, is 6,4 on the second, the breadth sought for. And if the length be 32 pole, the breadth to make an acre will be 5 pole.

PRO-

PROBLEM. IX

A plot of land being laid down, and cast up by any Scale, to find how much it well contain by any other Scale, either greater or lesser.

SUppose a plot of land being laid down, and cast up by a Scale of 10, in the inch, does contain 28,5 acres; and it is required to know how many acres it will contain, should it be cast up by a Scale of 12 in the inch.

Here because 12, the Scale to be used, is lesser than 10, the Scale formerly used: And so by consequence, the content of the given plot by the Scale of 12, will be more acres than it is by the Scale of 10 in the inch.

Therefore,

Set the Scale used 10 on the first, to the Scale to be used 12 on the second, and then against the content known 28,5 on the first, is 34, 2 acres, or neer thereabouts on the second: So much is the content by the Scale of 12 in the inch.

But if the plot had been laid down, and cast up by a Scale of 12, and the content required by a Scale of 10 in the inch, which is the greater Scale, and therefore the content is the lesser. Then.

Set 12 on the first, to 10 on the second,

 which

which done, right againſt the content in acres by the Scale of 12 on the firſt, is the content by the Scale of 10 on thc ſecond: As if the content by the Scale of 12 be 34,2 acres, then the content by the Scale of 10, will be found to be 28,5 acres neer. For,

Set 12 on the firſt, to 10 on the ſecond, and then againſt 34, 2 on the firſt, is 28,5 on the ſecond.

PROBLEM X.

The Diameter of a circle being given, to find the Circumference.

The Analogie ſtands thus:

AS 1 is to the Diameter; So is 3, 142 to the Circumference. Or,

As 7 to 22; So is the Diameter to the Circumference. If the Diameter be 15 inches what is the Circumference? Set 1 on the firſt, to 15 on the ſecond, and then right againſt 3,142 on the firſt, is 47,13 on the ſecond: So much is the Circumference of that circle. Or,

Set 7 on the firſt, to 22 on the ſecond, and then againſt 15 on the firſt, is 47,13 on the ſecond, as before.

PRO-

PROBLEM. XI.

The Circumference of a circle being given, to find the Diameter.

AS 22 is to 7, So is the Circumference to the Diameter. Or,

As 3,142 to 1, So is the Circumference to the Diameter. So if the Circumference be 47, 13, what is the Diameter?

Set 22 on the firſt, to 7 on the ſecond, and then againſt 47, 13 on the firſt, is 15 on the ſecond: So much is the Diameter of that circle. Or.

Set 3,142 to 1, and then againſt 47, 13 is 15, as before.

PROBLEM. XII.

The Diameter of a circle being given, to find the ſide of a Square equal to it.

THe Diameter of a circle is 15 inches, what is the ſide of the ſquare equal in Content?

Set 1 on the firſt, to 15 on the ſecond, and then right againſt this number 8862 on the firſt, is 13, 29 on the ſecond: So much is the ſide of a ſquare, that is equal in Content to that circle.

PROBLEM. XIII.

The Circumference of a circle being given, to find the side of a square, equal in Content to that circle.

LEt the Circumference of a circle be 47, 13, and the side of a square equal to it be required.

Set 1 on the first, to 47, 13 on the second, and then alwayes against this number 2821 on the first, is 13,29 on the second: So many inches is the side of a square, that is equal in Content to the circle given.

PROBLEM. XIV.

The Diameter of a circle being given, to find the side of a square, that may be inscribed within it.

LEt the Diameter of a circle be 15 inches, and it be required, what the side of that square will be, that may justly be inscribed within it?

Set 1 on the first, to that 15 on the second, & then against this number 7071 on the first, is neer about 10,6 on the second: Therefore 10,6 inches, is the side of a square that may be inscribed within a circle of 15 inches Diameter.

Or

Or thus it may be found:

Double the ſquare of the Semidiameter, the Root ſquare of that Product is the ſide of the ſquare inſcribed; but this is by the By.

PROBLBM. XV.

The Circumference of a circle being given, to find the ſide of a ſquare that may be inſcribed within it.

LEt the Circumference given be 47,13, & the ſide of a ſquare that may be inſcribed within it, be required,

Set 1 on the firſt, to the Circumference 47,13 on the ſecond; and then againſt this general number 2251 on the firſt, is neer about 10,6 on the ſecond: So many inches is the ſide of that ſquare, that can be inſcribed within the circle given.

PROBLEM. XVI

The Diameter or Circumference of a circle, either of them being given, to find the ſide of an Equilater triangle, to be inſcribed within that circle.

FIrſt, having the Diameter given, which ſuppoſe 14 inches, and it be required, to find the ſide of the Equilater Triangle that may be inſcribed in that circle. Set

Set 1 on the first,to 14 on the second,(that is,to the Diameter given) and then against this general number 8, 65 on the first, is 12,1 on the second: Therefore conclude, that 12 inches & one tenth part of an inch,is the length of the side of that Equailater Triangle, which may be inscribed within a circle of 14 Inches Diameter.

Or you may set 1 to the general number 865,and then against 14 is 12,1,as before.

Having the Circumference given,which let it be supposed to be 44,then to find the side of that Equilater Triangle,the work is thus.

Set 1 on the first, to the Circumference given 44 on the second, and then against this general number 272,6 on the first, is 12,1 on the second, the side of the Equilater Triangle sought for.

Or,Set 1 to that general number,272,6,and then against 44,is 12,1,and so of any other.

PROBLEM. XVII.

The Diameter or Circumference of any Circle being given, to find the superficial Content.

LEt the Diameter of a circle proposed be 15 Inches, and the superficial Content of it demanded.

Set 1 on the first, to 15 on the second, and then

then against this general number 7854 on the first, is 11,83 on the second ; and then again, against that 11, 83 on the first. is 176, 74 on the second : This 76, 74 is the Content of that circle proposed.

But if the Circumference of any circle only be given, as if it were given 47, 13, and the Content required. Then,

Set 1 on the first, to the Circumference given, 47,13 on the second ; and then against this general number 7958 on the first, is neer 37,8 on the second : And lastly, against this 37,8 one the first, is 176,74 on the second, the Content required.

PROBLEM. XVIII.

The Diameter, with the superficial Content of any circle to given, find the Content of any other circle that is twice the Diameter of the first.

LEt the Diameter of a circle given be 7 inches, & the Content 38, 5 inches, and the demand be, to know what another circle is that is double in Diameter to the former.

Set 7 on the first, to 14 on the second, and then against the known Content 38,5 on the first, is 77 on the second ; and then again, against that 77 found on the first, is 154 on the second: So much is the Content of that other circle,

circle, whose Diameter is double to the Diameter of the circle given, that is to say, of 14 inches Diameter.

PROBLEM. XIX.

The Content of a Circle being known, to find the Diameter and Circumference.

LEt the Content of a circle be known to be 176,74 inches, and it be required to know what the Diameter of that circle is, as also what the Circumference is.

For the Diameter, Set 1 on the first, to 1,273 on the second, and then against the Content known, 176,74 on the first, is 225 on the second; the square root of this 225 is 15: So many inches is the Diameter of that circle.

For the Circumferences, Set 1 on the first, to this general number 12,57, & then against 176,74 on the first, is neer 2221, wherof the square root is 47, 13: So many inches is the Circumference of that circle.

The Root square of the Content of any circle, is the side of a square equal to it.

CHAP.

CHAP. IV.

The Use of the double Scales in solid measure, such as Timber, Stone, &c.

PROBLEM, I.

The side of a square solid being given in inches, or feet, to find how much in length will make a foot solid in inches or feet.

Suppose the side of a square log be 25,45 inches, and demand is made, How many in length will make a foot.

Set the breadth given, 25, 45 on the first, to this general number 41, 57 on the second; and then against 1 on the first, is 1, 63 on the second, and against this 1,63 found on the first, is 2, 67 on the second: So much in length makes a foot of Timber, *viz.* 2 inches, and 67 parts of 100.

If the breadeth be given in parts of a foot (the foot being divided into 100 or 1000 equall parts) to find what parts of a foot in length will make a foot of Timber. As if the breadth of a piece of Timber be 2 foot & 120 parts of 1000 of a foot; then to find how much in length will make a foot solid.

Set

Set 2, 120 on the firſt, to 1 on the ſecond, and then againſt 1 on the firſt, is 471 on the ſecond; and laſtly, againſt that 471 on the firſt, is 222: So many parts of a foot (it being divided into 1000) do make a foot of Timber at that breadth.

PROBLEM II.

The breadth and depth of an unequal ſquare ſolid being given in parts of a foot, or in inches, to find how much in length will make a foot.

LEt the breadth of a piece of Timber be 2,5 foot, & the depth 1,8 foot. Here firſt by Multiplication find out the Content of the Baſe or end, which you ſhall find to be, 4,5, which being had, get the length of a foot ſolid thus:

Set the Content of the head found, 4,5 on the firſt, to 1 on the ſecond; and then againſt 1 on the firſt, is 222 on the ſecond: So many parts of a foot divided into 1000, do make a foot of Timber.

But if the breadth be given 30 inches, and the depth 21,6, then the Content of the Baſe will be 648, and the work thus wrought.

Set 648 on the firſt, to 1728 on the ſecond, and then againſt 1 on the firſt, is 11,27 on the ſecond; and laſtly, look this 11, 27 on the

firſt,

firſt, and right againſt it on the ſecond is 2,67 inches, the length of a foot of Timber in that log, whoſe breadth is 30 inches, & depth 21,6.

Or you may work thus:

Set 12 on the firſt, to 21, 6 on the ſecond, and then againſt 30 on the firſt, is 54 on the ſecond; This done, ſet the new found number 54 on the firſt, to 144 on the ſecond; and then againſt 1 on the firſt is 2,67 on the ſecond, the length to make a foot, as before.

Such an unequal ſquared piece of timber, as is here mentioned, may be reduced into a perfect ſquare, and wrought as in the firſt Problem. And ſo the perfect ſquare of this unequal ſquared log, whoſe breadth is 30 inches and depth 21, 6, will be found to be 2, 120 foot. Or 25,40 inches, & now you may proceed herewith, as in the firſt Problem you do with ſquare Timber.

PROBLEM. III.

The breadth of a ſquare ſolid, or the ſide of a ſquare equal to the Baſe of any unequal ſquare ſolid, and the length of the ſame ſolid being given in inches or feet, to find the Content in feet.

FIrſt, ſuppoſe the breadth and length be given in inches, as let the breadth be 25 inches,

ches, and 45 parts of an inch, and the length 183 inches, and the Content demanded.

Set this general number 41, 57 on the first, to the side of the square given 25, 45 on the second, and then against the length in inches 183 on the first, is 112 on the second: And again, against that 112 on the first, is 68,62 on the second: Therefore the Content of the piece of Timber proposed is 68 foot, and 62 parts of a foot into 100 divided.

But if the breadth be given in feet, & parts of a foot; As let the breadth of the solid be 2 foot, and 12 parts of a foot, such as the whole foot, is divided into 100, & the length 15 foot and 25 parts. Then.

Set 1 on the first, to 2, 12 on the second, that is to the breadth given, and then against 15,25 on the first, is 32,35 on the second: And lastly, against that 32,35 on the first, is 68, 62 on the second: So much is the Content in feet of that solid.

If an unequal squared solid be to be measured, it is as good a way as any, to reduce it to a perfect squared, & then compute the Content as here before, & this reduction is easily made for multiply the breadth by the thickness, & the Product is the Content of the Base, whereof the square root is the side of a perfect equal square, to that unequal square given.

PRO-

PROBLEM. IV.

The side of a squared solid given in inches, & the length in feet, to finde the Content in feet.

LEt the side of a perfect square solid be 25 inches, & 45 parts of an inch, such as the whole inch is divided into 100; & the length 15 foot, and 25 parts of a foot, Such as the whole foot is divided into 100, and the Content in feet required.

Set always 12 on the first, to the breadth in inches 25,45 on the second; and then against 15, 25 the length in feet, is 32, 35 on the second: This 32, 35 found on the first, and right against it on the second is 68, 62: So many foot of Timber, and parts of a foot, are in that log.

If an equal square solid be to be measured, reduce the Base of that unequal square solid into a perfect square, & then find the Content as here is taught.

PROBLEM. V.

The length, breadth and depth of a square solid being given in inches, to find the Content in feet.

BY the breadth & depth, get the Content of the Base; as let the length of a piece of

Timber be 183 inches, the breadth 20 inches, and the depth 13 inches, and the Content in feet desired: Here 20 and 13 multiplied together, make 260 for the Content of the Base.

Now, Set 1728 on the first, to 260, the Content of the Base on the second; and then against 138, the length on the first, is 27, 5 neer on the second: Wherefore you may conclude, that in the piece of Timber proposed is contained 27 foot and an half, with a little more, which is inconsiderable,

Or else you may work it thus:

Set 12 on the first, to 13 the depth on the second, and then against 20 the breadth on the first, is a fourth number, *viz.* 21,70 on the second. This done, Set 144 on the first, to this fourth number new found 21, 70 on the second; and then against 183, the length of the piece on the first, is 27, 5 on the second: So that the Content of that piece of Timber, is 27 foot and an half, as before.

Or you might have set 12 on the first, to 20 on the second, and then against 13 on the first, you should have had 21,70 on the second, for the fourth number, as afore, to which set 144 on the first, and then against 183, is 27 foot and an half.

PRO-

PROBLEM. VI.

The Baſe of any ſquare ſolid being given in Inches, and the length in feet, to find the Content in feet.

LEt the Baſe of a piece of Timber contain 260 inches and the length 15 foot and a quarter, and the content thereof in feet deſired.

Set 144 on the firſt, to the Content of the Baſe 260 on the ſecond; & then againſt 15,25 on the firſt, is 27, 5 on the ſecond. So then 27 foot and an half is the Content deſired.

If both the length and content of the Baſe be given in feet; then Set 1 on the firſt, to the Content of the Baſe in feet on the ſecond, and then againſt the length in feet on the firſt is the Content in feet on the ſecond: As if the length of a piece of Timber be 15 foot and a quarter, and the Content of the Baſe 4 foot and an half.

Set 1 on the firſt, to 4 & an half on the ſecond, and then againſt 15 and a quarter on the firſt, is 62, 68 on the ſecond; that is 68 foot & an half, and almoſt half a quarter: So much is the Content of that piece.

PROBLEM VII.

The Diameter of a Cylender given in inches or feet, to find the length of a foot, according to that Diameter.

LEt the Diameter of a Cylender, or round piece of Timber or Stone be 15 inches, & it be demanded, How much in length makes a foot ſolid?

Set the Diameter 15 on the firſt, to this general number 46,90 on the ſecond, and then againſt 1 on the firſt, is 3,13 on the ſecond; and then againſt that 3,13 found on the firſt, is 9,78 on the ſecond: So much in length makes a foot of Timber, that is 9 inches, and 78 parts of 100, of an inch.

But if the Diameter be taken in feet, and parts of feet, then ſet the Diameter 1,25 on the firſt, to this general number 1128 on the ſecond, and then againſt 1 on the firſt, is 9027 on the ſecond, and againſt this 9027 found on the firſt, you have 8,15 on the ſecond, that is 8 parts of a foot, ſuch as the whole foot is divided into 10 parts, and 15 parts of 100 of one tenth over: So much in length makes a foot.

PRO-

PROBLEM VIII.

The Circumference of a Cylinder given in inches or tenth parts of feet, to find the length to make a solid foot.

LEt the circumference of a round log be 47 inches, and 13 hundred parts of an inch, and the length to make a foot, desired.

Set the circumference 47,13 on the first, to 147,36 on the second, and then against 1 on the first, is 31,2 on the second; and against that 31, 2 on the first, is 9, 78 on the second: So many inches and parts in length make a foot solid.

But if the circumference be given in feet and parts of feet, as let the fore mentioned Cylinder be measured by feet, aud parts of feet, and be found to contain 3 foot and 93 parts of a foot. Then,

Set the circumference 3,93 on the first, to this number 35,45 on the second, and then against 1 on the first, is 903 on the second; and then against 903 found on the first, is neer 8,15 on the second: So much is the length in foot measure to make a foot.

PRO-

PROBLEM. IX.

The Diameter and length of a Cylinder given in inches or feet, to find the Content in inches, or tenth parts of feet.

LEt the Diameter of a Cylinder be 15 inches, and the length 105 inches, and the Content in inches ſought for,

Set this number 1128 on the firſt, to 15 on the ſecond, the Diameter known; and then againſt the length 105 on the firſt, is 1396 on the ſecond; and again, againſt this 1396 on the firſt, is 185 53,5 on the ſecond: The whole Content in inches, which divided by 1728, giveth 10 foot, and almoſt three quarters.

But if the Diameter and length be taken by foot-meaſure, as let the Diameter be 1,25 foot and the length 8,75 foot. Then,

Set the number 1128 on the firſt, to 1, 25 (the Diameter in foot meaſure) on the ſecond; and then againſt 8,75, the length on the firſt, is 9,69 on the ſecond. And laſtly, againſt 9, 69 on the firſt, is 10, 737 foot, or 10 foot, and almoſt three quarters: the Content ſought for, as before.

PRO-

PROBLEM. X.

The Diameter and length of a Cylinder given in inches, to find the Content in feet.

LEt the Diameter of a circle be 15 inches and the length 105 inches, and the Content in feet desired.

Set this number 4690 on the first, to 15 the Diameter on the second, and then against 105, the length on the first, is 33,58 on the second; and again, against this 33, 58 on the first, is 10,737 on the second: So then 10 foot, and almost three quarters, is contained in that Cylender.

PROBLEM. XI.

The Diameter of a Cylinder given inches, and the length in feet, to find the content in feet.

LEt a Cylinder be given to be measured, whose Diameter is 15 inches, and the length 8 foot, and 75 parts of 100 of a foot, and let it be required by these measures only to give the Content in feet.

Set this general number 1354 on the first, to 15 the Diameter on the second; and then against 8,75 the length in feet on the first, is 969 on the second: And lastly, against this 969 on

the first, is 10, 74 on the second : So much doth that Cylinder contain *viz.* 10 foot and almost three quarters.

PROBLEM. XII.

The circumference and length of a Cylinder given, in inches, to find the Content in inches.

LEt a Cylinder be given to be measured, whose length is 105 inches,& its circumference 47,13 inches,& let it be required only by these measures, to give the Content in inches, which to do:

Set this general number 3545 on the first,to 47, 13 on the second (that is the circumference) and then against 105,the length on the first, is 1396 on the second. Now again, against this 1396 on the first,is 18555 : So many inches are contained in that Cylinder.

PROBLEM. XIII.

The Circumference and length of a Cylinder given in inches, to find the content in feet.

LEt the fore-mentioned Cylinder be proposed, whose length is 105 inches, and the circumference 47,13 inches, and the content in feet required by this measure only. In this case.

Set

Set this general number 14736 on the firſt, to 47,13 on the ſecond, and then againſt 105, the length in inches, is 35, 58 on the ſecond, and againſt this 3358 on the firſt, is 10,71 on the ſecond, which is 10 feet and 74 parts of 100 of a foot.

But if the circumference and length be given in foot meaſure, as if the circumference be 3, 927 foot, and the length 8,75 foot, and the Content in feet required. Then,

Set this general number 3545 on the firſt, to 3,927 the circumference on the ſecond, and then againſt 8,75 the length on the firſt, is 969 on the ſecond; and again, againſt that 969 on the firſt, is 10,74 on the ſecond: So much is the Content in feet required.

PROBLEM. XIV.

The Circumference of a Cylinder taken in inches, and the length in feet, to find the Content in feet.

IN the Cylinder afore propoſed, having the circumference in inches 47,13, and the length in feet 8,75. I thereby to find the content in feet, do work thus:

Set this general number 4254 on the firſt, to the circumference in inches 47, 13 on the ſecond, and then againſt 8,75 the length in feet on

on the first, is 969 on the second ; and lastly, against this 969 on the first, is 10,74 on the second : So much is the content in feet.

PROBLEM. XV.

The Diameters of any vessel at the head, and at the bung, with the length in inches had, to find the content thereof, first in inches, and then in gallons, either of Wine or Beer.

LEt the length of a vessel be 40 inches, the Diameter at the head 18 inches, and the Diameter at the bung 32 inches, and the content of the vessel in inches and gallons is sought for. Which to find,

You must first get two third parts of the Content of a circle answerable to the Diameter at the bung; and one third part of the Content of a circle answerable to the Diameter at the head, & add them two numbers together, and their total multiply by the length of the vessel, and the Product is the Content in inches.

Now to get the two third parts of the circle at the bung ; Set 1 on the first, to this general number 5236 on the second, and then against 10 24, the square of 32, the Diameter at the bung is 536, 166, which is two third parts of the content of that circle at the bung.

For the one third part of the circle at the head,

head; Set 1 on the firſt, to this general number 2618 on the ſecond, and then againſt 324, the ſquare of 18 the diameter at the head on the firſt, is 84,823 on the ſecond, which is one third part of the content of the circle at the head.

Theſe two numbers 536, 166 and 84, 823 added together, make 609,980. This 620,989 multiply by 30, and it giveth 24839, 56: So many inches are contained in it.

And now to know how many Wine-gallons are in this veſſel, divide the content in inches 24839,56 by 231, which is the number of inches contained in a Wine-gallon, and the quotient is 107,53: So many Wine-gallons are in that veſſel.

To know how many Ale or Beer-gallons are in it, divide 24839,56 the content in inches, by 272,25, which is the number of inches in a Beer-gallon, the quotient is the content of the veſſel in Beer-gallons. How to multiply and divide is ſhewed before, and therefore I need not ſhew it here again.

CHAP.

CHAP. V.

The Use of the double scales of Numbers in Sphercial Bodies, such as Globes, Bullets, &c.

PROBLEM. I.

The Diameter of any Sphercical Body being known, to find the circumference.

Let the Diameter of a Bullet be 9 inches, and the circumference sought for.

Set 7 on the first, to 22 on the second, and then against 9 on the first, is 28, 28 on the second: So many inches is the circumference of a bullet of 9 inches diameter.

PROBLEM. II.

The circumference of any Spherical Body being known, to find the Diameter.

LEt the circumference of a Bullet be 28,28 inches, and the diameter sought for.

Set 22 on the first, to 7 on the second, and then against 28,28 on the first, is 9 on the second

cond, that is, 9 inches in the diameter of that Bullet, whoſe circumference is 28 inches, and 28 hundred parts of an inch.

PROBLEM III.

The Diameter and circumference of any ſpherical Body being known, to find the ſuperficial Content.

LEt the diameter of a Globe be 9 inches and the circumference 28,28 inches, and it is demanded, How many ſquere inches, the Superficies of that Globe doth contain? Then,

Set 1 on the firſt, to 9 the diameter on the ſecond, and then againſt 28,28 on the firſt, is very near 254,5 on the ſecond: So then 254,5 inches and an half, are contained in the Superficies of that Globe.

Or elſe by knowing only the diameter, work thus; Set 1 on the firſt, to this number 3,1416 on the ſecond; an then againſt 81, the ſquare of the diameter on the firſt, is 254,5 on the ſecond, as before; here you ſee are two ways of working, and both agreing: So that one proveth the other.

PRO-

PROBLEM IV.

The Axis or Diameter of a Globe being known, to find the solid Content.

IF the diameter of a Globe be 9 inches, what is the solid content in square cubick inches?

For resolving this and the like questions, the Rule is this; As the diameter is to the Cube of it self, So is 11 to the solid Content, The Cube of 9 the Diameter known is 729, which Cube, if you know it not, is thus found.

Set 1 on the first, to 9 on the second, and then against 9 on the first, is 81 the square of 9, on the second: and lastly, against this 81 on the first, is 729 on the second, which is the Cube of 9, the Cube being had.

Set 9 on the first, to 729 on the second, and then against 11 on the first, is 891 on the second: Therefore 891 cubick inches are contained in the solid body of that Globe. Or,

Set 9 on the first, to 9 on the second, and then against 11 on the first, is 99 on the second, and next against this 99 on the first, is 891 on the second, as before,

If the Diameter be 21 inches, then set 21 on the first, to 9261, its Cube on the second; and then against 11 on the first, is 4851 on the second:

ſecond: So many cubick inches are in a Globe of 11 inches diameter. Or,

Set 1 to 21, and then againſt 11 is 235, and againſt that 235 is 4851, as before.

PROBLEM V.

The diameter of a Bullet be given, with the weight; to find the weight of another Bullet of the ſame metal, but of another Diameter, either greater or leſſer.

LEt there be propounded an Iron Bullet of 6 inches diameter, weighing 30 pound, and let the queſtion be put, What another Bullet of the ſame metal will weigh, that is of 7 inches diameter?

Set 6 on the firſt, to 7 on the ſecond, and then againſt 30, the weight on the firſt, is 35 on the ſecond; Secondly, againſt 35 on the firſt, is 40,8 on the ſecond; Thirdly, againſt 40,8 on the firſt, is 47, 7 on the ſecond: So then the concluſion is, that 47 pounds, and 7 tenth parts of a pound, is the weight of that other Bullet of 7 inches diameter which was ſought for.

If a Bullet of 6 inches diameter, weigh 32 pounds, what will a Bullet of the ſame metal weigh, that is of 3 inches diameter?

Set 6 on the firſt, to 3 on the ſecond, and then

then againſt 32, the weight on the firſt, is 16 on the ſecond; Secondly, againſt 16 on the firſt, is 8 on the ſecond; and laſtly, againſt 8 on the firſt, is 4 on the ſecond: So then 4 pounds is the weight of that Bullet of 3 inches diameter.

PROBLEM. VI.

Having the ſide of a cubick body of Silver with the worth thereof, to find the worth of another cubick body of ſilver, whoſe ſide is greater, or leſſer than that of the body given.

If a Cube body of ſilver being 4 inches ſquare be worth 12 pounds, What will another Cube body of the ſame metal be worth that is 5 inches ſquare?

Set 4 (the ſide of the body whoſe worth is known) on the firſt, to 5 (the ſide of that body whoſe worth is ſought) on the ſecond; and then againſt 12, the worth known on the firſt is 15 on the ſecond; next againſt 15 on the firſt, is 18,57 on the ſecond; & thirdly, againſt 18,57 on the firſt. is 23,4 on the ſecond, which is 23 pounds and four tenths of a pound, that is 8 ſhillings: So then the worth of that cubick body of ſilver of 5 inches ſquare is 23 pounds and 8 ſhillings.

PRO-

PROBLEM. VII.

Having the weight of a Bullet of one kind of metal, to find the weight of a Bullet of another kind of metal, being equal in magnitude.

BEfore I proceed to reſolve this Problem, I will ſhew the proportions between ſome ſeveral metals uſed for this purpoſe, as of Braſs, Iron, Lead and Stone, according to the beſt approved Authors, as followeth.

The proportion between Lead and Iron is as 2 to 3, So that the Leaden Bullet of 3 pounds weight, is equal in diameter with an Iron Bullet of 2 pounds weight.

The proportion between Iron and Stone is as 3 to 8: Therefore a Stone of 3 pounds weight, is equal in bigneſs to a piece of Iron of 8 pounds weight, and a Stone body of 30 pounds weight, is equal in magnitude to an Iron body of 80 pounds weight, of the ſame form.

The proportion between Lead and Stone is as 4 to 1: So that a Bullet of Lead of 4 pounds weight, and a Stone Bullet of one pound weight, are equal in diameter; and a Leaden Bullet of 40 pounds weight, and a Stone Bullet of 10 pounds weight, are equal in diameter or magnitude.

The proportion between Iron and Braſs, is as 16 to 18; and the proportion between Lead and Braſs, is as 24 to 19.

Remember that ſome Stone is heavier than other, and ſo likewiſe of metals, the finer they are, the heavier they be, being of the ſame magnitude : but we ſpeak of the ordinary ſort in uſe. And now for reſolving the Problem.

Having the weight of a Bullet of Lead, to find the weight of a Bullet of Marble of the ſame bigneſs.

If a Bullet of Lead weigh 106 pounds, what will a Bullet of Marble weigh?

By the former Rule it is found, that a Bullet of Lead to the like Bullet of Marble, beareth ſuch proportion as 4 doth to 1. Therefore,

Set 4 on the firſt, to 1 on the ſecond, and then againſt 106 on the firſt, is 26,5 on the ſecond : So much is the weight of a Stone Bullet, that is equal in bigneſs to that Leaden one of 106 pounds weight.

On the contrary, having the weight of a Stone Bullet, to find the weight of a Leaden Bullet, of the ſame magnitude.

Set 1 on the firſt, to 4 on the ſecond, and then againſt 26, 5, the weight of the Stone Bullet on the firſt, is 106 on the ſecond, the weight of the Iron Bullet.

There is a Bullet of Iron weigheth 72 pounds,

pounds, What will a Bullet of Lead weigh that is equal to it in bigneſs?

Set 2 on the firſt, to 3 on the ſecond, and then againſt 72, the weight known on the firſt, is 108, the weight ſought for on the ſecond.

But if the weight of the Leaden Bullet be given 108, then to get the weight of the Iron Bullet, Set 3 on the firſt, to 2 on the ſecond, and then againſt 108 on the firſt, is 27 on the ſecond: So much is the weight of the Iron Bullet. What is ſaid of a Bullet, is to be underſtood alſo of all round bodies.

CHAP. VI.

The uſe of the double Scales in the Meaſuration of Concave Cylinders, ſuch as great Ordnance.

PROBLEM I.

The Diameter and weight of any one Cylinder, or Piece of great Ordnance being known, to find the weight of any other Piece of the ſame metal and ſhape, either greater or leſſer, its Diameter being onely known.

If a Braſs Saker, whoſe Diameter is 11, 5 inches, do weigh 1900 pounds, what will another Piece weigh, whoſe Diameter is 8,75 inches? For anſwer:

Set 11,5 on the firſt, to 8,75 on the ſecond, and

and then againſt 1900 on the firſt, is 1440 on the ſecond; Secondly, againſt that 1440 on the firſt, is 1100 on the ſecond; Thirdly, againſt the 1100 on the firſt, is 837 on the ſecond: So much is the weight of that other Piece of Ordnance of 8, 75 inches Diameter, it being of the ſame metal and ſhape as the other.

If a Piece of Ordnance of 4 inches Diameter weigh 1600 pounds, What will another Piece weigh that is 6 inches Diameter, being of the ſame metal and ſhape?

Set 4 on the firſt, to 6 on the ſecond, and then againſt 1600, the weight known, is 2400 on the ſecond; Next againſt 2400 on the firſt, is 3600 on the ſecond; And laſtly, againſt 3600 on the firſt, is 5400 on the ſecond. The weight ſought for of that other Piece of 6 inches Diameter.

PROBLEM II.

Having the Diameter and weight of any Piece of great Ordnance, of one; to find, the weight of another Piece of Ordnance of another metal, that retaineth the ſame ſhape.

A Piece of Ordnance being of another ſort of metal, there will be required a double work to find out its weight; As let there be a Braſs Piece of Ordnance given, of 11,5 inches

ches Diameter, weighing 1900 pounds; and let the queſtion be, to find the weight of an Iron Piece of Ordnance of the ſame ſhape, is 8,75 inches Diameter.

In this and the like caſes, you muſt in the firſt place, by the former Problem, find the weight of that Piece of 8,75 inches Diameter, as if it were a Braſs Piece, and having found that the weight of it,had it been Braſs,would have been 837 pounds: You muſt next ſeek the proportional numbers of the two metals, which by the ſeventh Problem of the laſt Chapter, you found was 16 and 18: Such is the proportion between Braſs and Iron, Braſs being the heavier metal, Therefore,

Set 18 on the firſt,to 16 on the ſecond,and then againſt 837 on the firſt,(the weight the Piece would have been of, had it been Braſs) is 744 on the ſecond,the weight of that Piece it being Iron.

PROBLEM. III.

To find the ſuperficial Content of the concave Supercies of any Piece of Ordnance, and alſo the ſolid Content of the Concavity thereof.

SUppoſe the Circumference of the Concavity be 12 inches,and the length of it 12 foot, or 144 inches, & the queſtion put, What is the ſuperficial Content of the concave face,

 and

and what the ſolid Content of the concave Bore. For the concave Superficies.

Set 1 on the firſt, to 22, the Circumference of the Concavity on the ſecond, and then againſt 144, the length in inches on the firſt, is 3168 on the ſecond: So many ſquare inches are in the Superficies of the concave face of the ſame Piece, which in feet makes 12.

For the ſolid Content.

Firſt get the Semidiameter, which in this example is 3,5 inches; and alſo the Semicircumference, which here is 11: Theſe being had,

Set 1 on the firſt, to 3, 5 the Semidameter on the ſecond, and then againſt 11, the Semicircumference on the firſt is, 38, 5 on the ſecond: So many ſquare inches are contained in the Baſe or Plain of the Concavity of the mouth. This Baſe had:

Set 1 on the firſt, to 38,5 the Content of the Baſe on the ſecond; and then againſt 144; the length in inches, is 5544 on the ſecond: So many cubick inches are in the ſolid Content of the Concavity of that Cylinder, which is 3 foot and 360 parts of 1728 of a foot.

PROBLEM IV.

To know how much of every kind of metal is contained in any Braſs Piece of Ordnance.

IT is ſaid to be an uſual thing with Gun-founders, that for every 100 pounds of Copper-

to

to put in 10 pounds of Latten, & 8 pounds of pure Tin. Now ſuppoſing this mixture to be true, let it be demanded, How much of every ſort of theſe metals is in a Gun of 5600 pounds weight?

For anſwer to this and the like queſtions; Firſt, joyn all the ſeveral mixtures together that is, 100, 10, & 8, and this muſt be the firſt number in the Rule of proportion; the weight of the Piece the ſecond number, which here is 5600; and the third number is each ſeveral ſort of metal in the mixture, which here be 100, 10. & 8, wherefore by our double lines, this *Quære* is very eaſily reſolved. For,

Set 118, the total of the common mixture on the firſt, to 5600, the weight of the Piece on the ſecond, and then againſt 100 on the firſt, is 4745,7 on the ſecond, againſt 10 on the firſt, is 474, 6 on the ſecond, being one place leſs than the former, becauſe 10 is one place leſs than 100; ſo much Latten is in that Piece: and againſt 8 on the firſt, is 379, 7 on the ſecond, ſo much Tin is in the Gun.

Now if all theſe three ſums thus found be added together, they make the juſt weight of the Piece propounded, as here it doth appear, and proveth the work truly wrought.

4745,7
474, 6
379, 7
5600,0

PROBLEM. V.

By knowing what quantity of powder will load some one Piece of Ordnance, to find how much of the same powder will load any other Piece of Ordnance, greater or lesser.

IF a Saker of 3, 75 inches Diameter in the Bore, require four pounds of powder for its load, What will a Demi-Canon of 6,5 inches Diameter in the Bore require?

Set 3,75 on the first, to 6,5 on the second, and then against 4, the weight known on the first, is 6, 93 on the second, and then against that 6,93 on the first, is 12 on the second; and lastly, against that 12 on the first, is 20, 8 on the second, very neer; that is, 20 pounds of powder, and 8 tenth parts of a pound: So much doth the Demi-Canon require.

But note, that it is here understood, that the Demi-Canon ought to be as well fortified as the Saker is, that is, it should bear the same proportion to the Saker in weight and thickness of metal, that the bore thereof beareth to the bore of the Saker, as in this example; The bore of the Saker is 3 inches and 3 quarters, the Cube whereof is 52, 73, and its weight is 1600 pounds; The bore of the Demi-Canon is 6 inches and an half, the Cube whereof

whereof is 274,62. Now the queſtion is, How much the weight of that Demi-Canon ought to be, that is proportional in its weight and thickneſs to the Saker, that ſo it may be able to bear a load of powder proportional to the Saker.

The weight of ſuch a Demi-Canon is thus found; Set 52, 37 the Cube of 3, 75 on the firſt. to 274,62 the Cube of 6,5 on the ſecond, and then againſt the weight of the Saker 1600 on that firſt, is 8351 on the ſecond: The weight that the Demi-Cannon ought to be of, that is proportional in weight to the Saker, and able to carry a load of powder proportional to the Saker. Or you may work it thus without the Cubes.

Set 3, 75 on the firſt, to 6, 5 on the ſecond, and then, firſt againſt 1600 on the firſt, is 2766 on the ſecond; ſecondly, againſt this 2766 on the firſt is 4800 on the ſecond; and thirdly, againſt that 4800 is 8351 on the ſecond, as before: So the one proveth the other.

But if the Demi-Canon be found to want of its proportional weight with the Saker, as if it weigh but 6000 pounds, then to find its due load in powder, anſwerable to its ſtrength & weight of metal; Multiply the weight thereof 6000, by 20,8 the charge already calculated, & divide the Product by 8351, the weight it ought

ought to have had, and the quotient is 14,8: Therefore 14 pounds, and 8 tenth parts of a pound, is a ſufficient charge for ſuch a Gun.

By our lines, Set 1 on the firſt, to 20, 8 on the ſecond, and then againſt 6000, is 1248000, the Product. Now ſet 8351 the Diviſor on the firſt, to 1 on the ſecond, and then againſt 1248000 on the firſt, is 14, 8 on the ſecond, the quotient ſought.

But ſuppoſe there be another ſort of powder brought to be uſed, that is ſtronger than the former, by ſuch proportion as 5 is to 2. How much of this ſort will ſerve to charge that Gun, which required 14,8 pounds of the other ſort. For anſwer of this *Quære*.

Set 5 on the firſt, to 2 on the ſecond, and then againſt 14,8 on the firſt, is 5,9 and a little above: Therefore 5 pounds of powder, and 8 parts of 10 of a pound, of this new ſort of powder, will charge the Gun, having as much ſtrength to carry forth the Bullet, as 14 pounds and 8 tenths of the other.

PRO-

PROBLEM. VI.

Knowing how far any Piece of Ordnance will carry her Bullet at point-blank, and at the best of her Randon, to find how far any other Piece of Ordnance will carry her Bullet at her best Randon, her level-range being known.

A Saker at point-blank conveyes her Bullet 200 paces, and at her best Randon 900 paces. Now how far will a Canon carry her Bullet at her best Randon, that carrieth it at point-blank 360 paces.

Set 200 on the first, to 900 on the second, and then against 360, the other Pieces point-blank on the first, is 1620 on the second: The number of paces it will carry at point-blank.

If the best Randon and point-blank of the onc Piece be given, with the best Randon of the other Piece, to find the point-blank thereof.

Set 900, the best Randon on the first, to 200 its point-blank on the second, & then against 1620, the other Pieces best Randon on the first, is 360, its point-blank on the second.

PRO-

PROBLEM. VII.

By knowing how far any piece of Ordnance will carry a Bullet at the best of her Randon, to find how far she will carry her Bullet at any other degree of Randon.

IF a Piece at her best Randon, which is 45 degrees of Mounture, carry her Bullet 1440 paces, How far wil she carry it at 30 degrees of Randon?

Set 45, the best Randon on the first, to 30, the other Randon on the second, and then against 1440, the paces of her carriage at her best Randon on the first, is 960; the paces of her carriage at 30 degrees of Randon; and if you take 960, from 1440, the remain is 480: So much doth she shoot short of her best Randon.

If a Gun carry a Bullet 700 yards at her best Randon, which as aforesaid is at 45 degrees, and the mark to shoot at be distant but 500 yards; To what degree must the Gun be mounted to a make a good shoot?

Set 500 on the first, to 700 on the second, and then against 45 on the first, is 63 on the second; or bring 500 to 55, and then against 700 is 63, which is 63 degrees: Therefore the Piece must be raised to 63 degrees of Mounture

Mounture, to make a good ſhoot into the place.

Note, this queſtion is reſolved by the backward Rule of Three.

If a Gun at her beſt Random ſhoots 500 yards, How much will ſhe ſhoot ſhort of it, being elevated two degrees above her beſt Randon?

Set 45, the degrees of beſt Randon on the firſt, to 2 the degrees ſhe is elevated above it. on the ſecond, and then againſt 500, is 22,22: So many yards will ſhe ſhoot ſhort of her beſt Randon, being elevated 2 degrees above it

How far is it to the place where a Bullet falleth, the Piece being mounted 15 degrees above her beſt Randon, ſhe abating 22,22 for 2 degrees elevation?

Set 2 on the firſt, to 22, 22 on the ſecond and then againſt 15 on the firſt, is 167 on the ſecond; therefore the Gun being raiſed 15 degrees above her beſt Randon, abateth 167 yards of the 500, her carriage at her beſt Randon. wherefore 167 taken from 500: leaveth 333: So many yards is the place diſtant where the Bullet falleth.

If a Gun ſhoot point-blank 240 paces, and being mounted to one degree, doth out-ſhoot the point-blank 30 paces, What will ſhe out-ſhoot it at 20 degrees of Mounture?

Set

Set 1 on the firſt, to 30 on the ſecond, and then againſt 20 on the firſt, is 600 on the ſecond: So many paces will ſhe out-ſhoot her point-blank, being mounted 20 degrees, in the whole ſhot 840 paces.

PROBLEM. VIII.

To find out how much wide of the mark any Piece of Ordnance will ſhoot, by knowing how far it is to the mark ſhot at, & how wide the Pieces mouth lieth from the right line to the mark.

A Gun of 10 foot, or 120 inches long; being to ſhoot at a mark 700 yards diſtant, her mouth lying one inch beſide the right line to the mark, How far will ſhe ſhoot her Bullet wide of the mark at that diſtance?

For anſwer: Firſt, bring 700 yards into inches, and they make 25200, which is done by Multiplication thus;

Set 1 on the firſt, to 36 on the ſecond, for that is the number of inches in a yard, & then againſt 700, the diſtance on the firſt, is 25200, the inches in 700 yards. And then,

Set 120 on the firſt, the Guns length in inches, to 1; and then againſt 25200, the diſtance in inches, is 210 inches, or 17 foot and an half: So far the Bullet goeth wide of the mark.

PRO-

PROBLBM. IX.

Knowing the quantity of each ſort of Ingredients for the making of Gun-powder, to find how much of every ſort is to be put into any quantity of powder that ſhall be required to be made,

I Have read in ſome Authours, that for making of the beſt ſort of ordinary Gun-powder, there is uſed to be taken 12 parts of Mercury, three parts of Cole, and two parts of Sulphur, in all 17 parts. Now a Gun-powder-maker is appointed to make 1000 pound weight of powder, How much muſt he take of each ſort of theſe Ingredients, to make that quantity of powder?

Set 17, the ſum of the parts on the firſt, to 1000, the quantity to be made, one the ſecond; and then without more ado, on the firſt, right againſt 12 is 706, and againſt 3 is 176,5; and laſtly againſt 2 is 117,5 on the ſecond. Theſe three ſums being added together, make juſt 1000. Therefore you may conclude, that to make 1000 pounds of Gun-powder, he muſt take of Mercury 706 pounds, of Cole 176,5, and of Sulpher 117,5 pounds the thing required.

red. This Problem is grounded upon the rule of Proportion thus:

As 17, the whole parts taken,
Is to 1000 the quantity to be made:
So is each ſeveral part of the mixture.
To the quantity thereof to be taken towards the making of 1000 weight.

I might have put down the Analogies of Proportion all along, as I did at the beginning; but I thought thoſe things would have filled my book too faſt, and every man that knowes the rule of Proportion, cannot but ſee how every Problem is reſolved thereby.

CHAP.

CHAP. VII.

The use of the double Scales in Fortification.

THe side of a Pentagonal Fort being propounded, with the perpendicular, and all the other lines, with the Area; To find the sides and all other lines and Content of any other Pentagonal Fort, that shall be required to be made, either greater or lesser, according to any proportion assigned.

Suppose there be a Pentagonal Fort made, such an one as is represented by this Diagram annexed, noted by the letters A B S T X K O G F E D N M L H P and C, whose sides A B, B S, S X, X R, and K A, are each 662 yards, And let it be required; to make another Fort that shall be a just fourth part in Content of ground of that propounded Fort. Now the Content of the propounded Pentagonal Poligon, described by the letters A B S X K, is 75 4680 yards, and the sides and lines of the Fort thereon made as are followeth,

The side of the Pentagon A B, is 662 yards.

The Perpendicular C I, 456 yards.

The Semidiameter of the Pentagon C A, 564 yards.

The Gorge-lines of the Fort A D, A O, N B, B *P*, each one of them 119 yards.

The Flanks of the Bulwark D E, O G, 100 yards.

The Curtain D N, 424 yards.

The Fronts lines, F E, F G, and L M, L H, 264 yards.

The Head-lines, or Capital A F, or B L, 224 yards.

The breadth of the Bulwark from G to E, or M to H, 330 yards.

The Lines of Defence D L, and N E, 700 yards.

The diſtance between the points of the Bulwark F and L, is 926 yards.

The Line perpendicular to the Line F L, *viz.* C R, 637 yards.

By theſe Lines and lengths known, it is required to make another Pentagonal Fort, whoſe quantity or Content in land ſhall be the juſt fourth part of the propoſed Pentagonal Fort propounded: where note, that the half of the ſides and lines of the Fort made will make another Fort, that will contain the fourth part of the ground in that Fort made: And that you may readily have half of all the lines of the Fort made, do thus: Set

Set 2 on the firſt, to 1 on the ſecond, and then againſt the number of any line on the firſt, is its half on the ſecond: As againſt 662, the length of the ſide of the Pentagon given, is 331, the length of the Pentagons ſide to be made. The Lines thus remaining without any moving, againſt 119 on the firſt, the length of the Gorge-line in the made Fort, is 59,5, the length of the Gorge-line in that Fort to be made: And againſt 424, the length of the Curtain in the made Fort, is 212 on the ſecond the length of the Curtain in that Fort to be made: And againſt 456, the length of the propoſe Poligons perpendicular which is made, is 228, the length of the perpendicular in that Poligon which is to be made: And againſt the Semidiameter 564, is 282: And againſt 100, the length of the preſent Bulwarks flank, is 50, the length of the Flank in the Bulwark to be made. And againſt 224, the length of the Bulwarks head-line, is 112, the length of the head line in the Fort to be made: And againſt 310, the diſtance of the ſhoulders GE, or M H in the Fort made, is 155, for the diſtance of the ſhoulders in that Fort which is to be made: And in like manner, againſt the length of any Line in the propoſed Fort is the length of that ſame Line in the Fort to be made.

Thus very ſpeedily is found out the true

ength of all the Lines in and belonging to ſuch a Fort as is required to be made, whoſe lines and ſides ſhall be juſt half the length of thoſe in the Fort already made: And being drawn on the ground, and made up, will in all parts be like and proportional to the ſame propoſed Fort. The like manner of working is to be uſed for any other proportion whatſoever, either greater or leſſer.

Suppoſe it were required to make a Pentagonal Fort, whoſe ſides, and ſo all the lines thereof, ſhould be the one third part in length of the ſides and lines in that propoſed Fort, which in the annexed Diagram is repreſented by the letters **C A B S T XK O G FE DNM L P H.** To which demand, to give a ready anſwer, do thus:

Becauſe one third part is ſought for, Set 3 on the firſt, to 2 on the ſecond, and then againſt 662 on the firſt, the ſide of the Pentagon given, is 220 $\frac{2}{3}$ on the ſecond, which is one third part of 662, & ſheweth that the length of the ſide of the Pentagon to be made is 220$\frac{2}{3}$ yards; and againſt 119, the length of the Gorge-lines in the propoſed Fort, is 39$\frac{2}{3}$, that is 39 yards 2 foot, which is the third part of 119, and is the juſt length of the Gorge-lines in the Fort to be made. In like manner, againſt any Line or diſtance in the propoſed Fort, is the length of

of the ſame Line in that fort to be made. For to be ſhort, Take any number on the firſt, and right againſt it on the ſecond, is the one third part thereof.

How to make a Fort greater than the Fort propoſed.

SUppoſe there be a fort made, ſuch an one as is that repreſented in the afore-mentioned Diagram, and another Fort is to be made like to it; ſo that in all the lines and ſides thereof; it be double to thoſe in the Fort that is already made.

In this caſe and the like, we have no more to do, but to ſet 1 on the firſt, to 2 on the ſecond, and then againſt the number of the length of any ſide or line on the firſt, is the double of it on the ſecond. As if you ſet 1 on the firſt, to 2 on the ſecond, then againſt 456 on the firſt, the length of the perpendicular in the Pentagonal Fort given, you ſhall have 912 on the ſecond, the double of 465, which is the length of the perpendicular in that Fort to be made; and againſt 662, the length of the Curtain in the Fort made, is 1322, the length of the Curtain in the Fort to be made: And ſo of all the reſt of the Lines.

If it ſhall be required to make ſuch a Fort, as in its ſides and lines ſhall be one third part longer than thoſe in the propoſed Fort: Then

take any one line, as for example, C I 456 yards, and thereof take the one third part, which is 152 : This add to the ſame 456, and it makes 608. This done, Set 456 on the firſt, to 608 on the ſecond, and then againſt any line of the Fort made on the firſt, in its match-line in the Fort to be made. As againſt D N, the Curtain in the made Fort, 424 yards, is 565 $\frac{1}{3}$: So many yards will the Curtain be in that Fort to be made, and ſo of all other lines. And if a Fort be to be made, whoſe ſides and lines muſt be half ſo much more in length, as are the ſides and lines of the propoſed Fort: Then take the half of any number, and add it to the ſame number, and ſo proceed as before.

Note, that the lines in the Type or Diagram annexed, may be accounted in their lengths there ſat down, either ſo many foot, or ſo many yards, or ſo many perches, or what other meaſure you are to uſe: And ſo the ſide of the Pentagon 662, may be accounted 662 yards, or 662 foot, or 662 perches. Thus by ſuppoſing a Pentagonal Fort to have lines and ſides in length, as thoſe in the Diagram, you may by theſe double lines very eaſily diſcover all the lines and ſides of any other Pentagonal Fort, either greater or leſſer.

CHAP.

CHAP. VIII.

The Use of the double Scale of Sines in Astronomy.

PROBLEM. I.

The Suns greatest declination, with his place or distance from the next Equinoctial point being given, to find his present declination for the time given.

THe Suns greateſt declination in this our age, is found to be 23 degrees 30 minutes. This is general, his place given on the day propoſed, is 0 degrees of *Taurus*, which point is diſtant from the next Equinoctial point of *Aries* 30 degrees.

The Analogie for Solution of this Propoſition is thus:

As the Radius, or Sine of 90 degrees, Is to the Suns greateſt declination 23 deg. 30 min. So is the diſtance of the Sun 30 deg. from the next Equinoctial point which is *Aries*, To the Sine of the declination 11 degr. 30 min. ſought for. Wherefore,

Set 90 degrees on the firſt, to the Suns greateſt declination 23 deg. 30 min. on the ſecond,

and then againſt 30 deg. the Suns diſtance from the next Equinoctial point on the firſt, is 11 deg. 30 min. on the ſecond : So much is his declination ſought for, his place being the very beginning of *Taurus*.

Suppoſe the Sun be in the beginning of *Leo*, which is 60 degrees diſtant from the Equinoctial point of *Libra*; then ſet 90 deg. on the firſt, to 23 deg. 30 min. on the ſecond, and then againſt 60 deg. on the firſt, is 20 deg. 10 min. on the ſecond : The declination of the Sun, when he is entring into *Leo*.

PROBLEM. II.

The Suns greateſt declination, and his preſent declination for any time propoſed being had, to find his diſtance from the next Equinoctial point, and thereby his place in the Ecliptick.

SEt the Suns greateſt declination, 23 deg. 30 min. on the firſt, to 90 degrees on the ſecond; and then againſt his preſent declination, being given 11 deg 30 min. on the firſt, is 30 degrees on the ſecond: So much is his diſtance from the next Equinoctial point, which is *Aries* ; therefore his true place is juſt leaving *Aries*, and entring *Taurus*.

Again, ſuppoſe the Suns preſent declination be given 20 deg. 10 min. and his place ſought: Set

Set 23 deg. 30 min.on the firſt, to 90 deg. on the ſecond, and then againſt 20 deg. 10 min. on the firſt, is 60 degrees on the ſecond: So much is the Suns diſtance from the next Equinoctial point.

Now if the Sun be in the firſt quarter of the Ecliptick,between *Aries* and *Cancer*,then he is diſtant from the Equinoctial of *Aries* 60 degrees,& therefore in the beginning of *Gemini*: But if he be in the ſecond quarter of the Ecliptick,as in this propoſal he is, his diſtance is to be accounted from the Equinoctial of *Libra*, & then his place muſt be in the beginning of *Leo*; If he be in the third quarter of the Ecliptick,and 60 degrees from the next Equinoctial point, then he is in the beginning of *Sagittarius*: And if he be in the fourth quarter of the Ecliptick, and diſtant 60 degrees from the next Equinoctial point, then he muſt be in the beginning of *Aquarius*

PROBLEM. III.

The Suns declination, & the Latitude of the place being given, to find the Suns Amplitude,

LEt be given the Suns declinations. 11 deg. 30 min. & the Latitude of the place propoſed 51 degrees, 30 minutes, whoſe Complement to 90 degrees, is 38 degrees, 30 minutes:

nutes: And the Amplitude ſought for.

Set the Co-ſine of the Latitude 38 deg. 30 min: on the firſt, to the Radius, or 90 degrees on the ſecond, and then againſt the ſine of the Suns declination, 11 deg. 30 min. on the firſt, is 18 deg. 40 min. on the ſecond: So much is the Suns Amplitude, at ſuch time as his declination is 11 deg. 30 minutes. Or,

Suppoſe the Suns, or a Stars declination were known to be 20 degrees, then without altering the lines from the place they were firſt ſet to, right againſt 20 deg. on the firſt, is 33 deg. 10 min. on the ſecond, the Amplitude ſought: And ſo againſt any other declination on the firſt, is the Amplitude on the ſecond.

PROBLEM. IV.

The Latitude of the place, the Suns greateſt declination with his diſtance from the next Equinoctial point being had, to find his Amplitude.

THe Latitude is 51 deg. 30 min. whoſe Complements is 38 deg. 30 min. the Suns diſtance from the next Equinoctial point is 18 deg. 40 min, and his greateſt declination 23 deg. 30 min. an the Amplitude required.

Set the Co-ſine of the Latitude, 38 deg. 30 min. on the firſt, to 23 deg. 30 min on the ſecond, the ſine of the greateſt declination, and then

then againſt 30 degrees,the diſtance from the neereſtEquinoctial point on the firſt,is 18 deg. 40 min. on the ſecond : So much is the Suns Amplitude,when his place is in the beginnings of *Taurus*, *Virgo*, *Scorpio*, or *Piſces*.

PROBLEM. V.

TheLatitude of the place,theSuns place or diſtance from the next Equinoctial point,with his greateſt declination being known; to find what altitude the Sun will have, when he is on the true Eaſt or Weſt point.

LEt the Latitude be 51 deg. 30 min. the Suns place in 10 degrees of *Taurus*,which is diſtant from the next Equinoctial point 40 degrees,and the greateſt declination 23 deg. 30 min. What is the Suns altitude at the true Eaſt or Weſt point?

Set 51 deg. 30 min.on the firſt, (the Latitude of the place)to 23 deg.30 min.the greateſt declination on the ſecond;& then againſt 40 degrees, the diſtance from the neereſt Equinoctial point on the firſt, is 19 degr. 5 min, on the ſecond : So much is theSuns altitude, when he is on the true Eaſt or Weſt point:And at his entrance into *Taurus*, his altitude at that point is 14 degrees 45 minutes. As this, ſo his altitude for any other place is found,

found, without stirring the lines, after once set together.

PROBLEM. VI.

The Latitude of the place, and Suns declination being had; to find what altitude the Sun will be of, when he cometh upon the true East or West point.

LEt the Latitude be 51 deg. 30 m. and the Suns declination 11 deg. 30 min. and his height at his being on the due East or West point required.

Set the sine of the Latitude, 51 deg. 30 min. on the first, to the Radius on the second, and then against the sine of the given declination 11 deg. 30 min, on that first, is 14 degr. 45. min. on the second. So much is the Suns altitude at the time of his being due East or West when his declination is 11 deg. 30 min.

PROBLEM. VII.

Having the Suns greatest declination, and his distance from the next Equinoctial point; to find his right ascension.

THe Suns greatest declination is 23 degr. 30 min. and his place given is 0 degr. of *Taur.* Therefore his distance from the nearest Equi-

Equinoctial point *Aries* is 30 degrees: By these known, his right Ascension is desired.

Set 90 deg. on the first, to the Co-sine of the greatest declination, 66 deg. 30 min. on the secoud; and then on the back-side, (being the lines of *Tangents*) against the *Tangent* of 30 degrees, the Suns distance from the neerest Equinoctial point on that first, is the *Tangent* 27 degr. 50 min. So much is the Suns right ascension at that time.

PROBLEM. VIII.

The Suns greatest declination, and his present declination, being given for a time; to find his right ascension for that time.

THe Suns greatest declination is 23 degr. 30 min. and his present declination for a time proposed, is 11 deg. 30 min. I demand his right ascension thereby.

Set the *Tangents* of 23 deg. 30 min. on the first, to the *Tangent* of the present declination, 11 deg. 30 min. on the second; and then upon the other side, on the lines of sines against the Radius on the first, is the sine of 27 degr. 50 min. on the second: So much is the Suns right ascension demanded.

PRO-

PROBLEM. IX.

The Latitude of the place, and the Suns declination known; to find how long the Sun riseth and setteth, before or after the hour of six.

THe Latitude of the place is 51 degrees, 30 minutes North, and the Suns declination 11 degrees, 30 minutes. I demand the time of Sun-rising before six.

Set the Co-tangent of the Latitude, 38 deg. 30 min. on the first, to the Tangent of 11 deg. 30 min. the declination given on the second; & then on the other side, against the Radius on the first, is the sine 14 deg. 50 min. This 14 deg. 50 min. converted into time, by accounting four minutes of an hour to every degree, & one minute of an hour for 15 minutes of a degree, and it will amount to 59 minutes of an hour: So long the Sun riseth before six in the morning, & sets after six at night in the Summer season; and in the Winter season, or Southern sines, he riseth so long after six in the morning, and sets so long before six at night, where the Latitude is 51 deg. 30 minutes, and when the Suns declination is 11 deg. 30 min. South.

PRO-

PROBLEM. X.

The Sun being in the Equinoctial, by knowing his distance from the Meridian, and the latitude of the place; to find the Suns altitude at that time.

MArch the tenth, the Sun being in the Equinoctial at ten a clock before noon, or at two a clock after noon, he being at that hour distant from the Meridian 30 degrees, I would known his height in our Latitude of 51 deg. 30 minutes.

Set the Radius on the first, to the Co-fine of the Latitude, 38 deg. 30 min. on the second, and then against the Co-fine of the Suns distance from the Meridian, *viz.* against 60 degrees on the first, is 32 deg, 37 minutes on the second; So much is the Suns altitude on the tenth of March, at ten a clock in the fore-noon and at two a clock afternoon.

PROBLEM. XI.

The Latitude of the place, and the Suns declination Northwards being known; to find the Suns altitude, at the hour of six.

LEt the Latitude of the place be 51 deg. 30 min. the Suns declination 14 deg. 50 min, North-

North: And the Suns height at six a clock is desired.

Set the Radius on the first, to the sine of the declination, 11 deg. 50 min. on the second; and then against 51 deg. 30 min. the Latitude; on the first, is 8 deg. 58 min. on the second: So much is the Suns height at the hours of six at morning and night. Or else thus:

Set the Radius to 51 deg. 30 min. and then against 11 deg. 50 min. on the first, is 8 degrees 58 minutes on the second: For note, that the Radius on the first may be set to either of the other two terms given on the second, and then against the other term on the first, is the answer on the second.

PROBLEM. XII.

The Latitude and declination of the Sun being known; to find the Suns Azimuth at the hour of six, from the North part of the Meridian.

IN the Latitude of 51 deg. 30 min. the Suns declination given is 11 deg. 30 min. What is his Azimuth at the hour of six?

Set the Radius on the first, to the Co-sine of the Latitude, 38 degr. 30 min. on the second; and then against the Co-tangent of the declination, 11 deg. 30 min. on the first, is the Tangent 82 deg. 47 min. on the second: So much

much is the Suns Azimuth from the North towards the East, which was required.

PROBLEM. XIII.

The Latitude of the place, and the Suns altitude at the point of his being due East or West; to find the hour and minute when he will be so due East or west.

THe Latitude of the place is 51 degrees, 30 min. The Suns height found at his being on the true East point, is 14 deg. 45 min. I demand the hour of the day.

Set the Radius on the first, to the Co-sine of the Latitude, 38 deg. 30 min. on the second; and then on the Lines of Tangents, right against the Tangent of the Suns altitude, at his being due East, *viz.* 14 deg. 45 min. on that first. is 9 deg. 18 min. on the second, the Tangent of time from the hour of six, either before or after, that the Sun will be due East, or due West. This 9 degr. 18 minutes reduced into time, by allowing to every degree four minutes of time, and for fifteen minutes of a degree, one minute of time, amounteth to 37 minutes of time: So then the Sun is due East on the day given, at 37 minutes after six a clock in the morning; and also will be

due West at 36 minutes before six at Night, which is at five a clock 23 minutes.

PROBLEM. XIV.

The elevation of the Pole, the Suns (or Stars) declination, and distance from the Meridian for any time being given; to find the Suns altitude at that time.

Let the elevation of the Pole be 51 deg. 30 min. whose Complement to 90, is 38 deg. 30 min. The Suns declination 11 deg. 30 minutes, whose Complement is 78 deg. 30 min. his distance from the Pole; his distance from the Meridian 30 degrees, or which is all one, two hours, that is, either at ten or two a clock, and the Complement of this distance to 90 degrees, is 60 degrees: And let the Suns Altitude for that time be required.

1 Set the Radius on the first, to 60 deg. the Co sine of the Suns distance from Noon on the second; and then on the lines of Tangents against 38 deg. 30 minutes, the Co-tangent of the elevation on the first, is the Tangent 34 degrees, 33 min. on the second; for the fourth term, which taken from the Suns distance from the Pole, the Remainder is 43 degrees, 56 minutes.

2 Set

2 Set the Co-fine of that 34 deg. 33 min. the fourth term, *viz.* 55 deg. 27 min. on the firſt, to 46 deg. 4 min. the Co-fine of that Remainder on the ſecond; and then againſt the fine of the Elevation, 51 deg. 30 minutes on the firſt, is the fine 43 deg. 18 min. on the ſecond: So much is the altitude of the Sun at that time, the thing required.

This is when the Sun hath Northern declination, but when he hath Southern declination then add his declination to 90 degrees, and it makes 10 1 deg. 3c min. the Suns diſtançe from the Pole, from which take the fourth term found, and the Remain is 66 deg. 27 min. This done, the ſecond work would be thus:

Set the Co-fine of the fourth term found on the firſt. *viz.* 55 deg. 27 min. to the Co-fine of that Remain, which is 23 deg. 33 min. on the ſecond; and then againſt 51 deg. 50 min. the Elevation on the firſt, is 21 deg. 52 minutes on the ſecond. The Suns height at ten or two a clock, when he hath 11 degrees 30 minutes of South declination.

If the Sun be juſt in the Equinoctial, having no declination; then to find his height on that day at ten or two a clock, the work will be done at one working in this manner,

Set the Radius on the firſt, to 60 degrees, the Co-fine of the diſtance from the Meridian

on the ſecond ; and then againſt 38 degrees, 50 min. the Co-ſine of the Elevation on the firſt, is the ſine 32 deg. 62 min. So much is the Suns altitude at the hours of ten and two a clock on the Equinoctial day.

PROBLEM. XV.

Having the Poles elevation, and the Suns declination, to find the aſcenſional difference.

LEt the Poles elevation be 51 deg. 30 min. and the Suns declination 11 deg. 30 min. And by them the aſcenſional difference requited to be given.

Set 38 deg. 30 min. the Co-tangent of the elevation on the firſt, to the Tangent of the declination 11 deg. 30 min. on the ſecond ; and then (on the Lines of Sines) againſt the Radius on that firſt, is the ſine of 14 deg, 49 min. on the ſecond : So much is the aſcenſional difference required at that time, as the Sun hath 11 deg. 30 min. declination.

I could ſhew by this aſcenſional difference converted into time, How to find the time of Sun-riſing and ſetting, with the length of day, and night, &c. But theſe are things done without the Lines, and therefore I paſs them by, having limited my ſelf to ſhew only the uſe of the double Lines.

PRO-

PROBLEM. XVI.

Having any Planets declination & Latitude, with its distance from the next Equinoctial point; to find its right ascension.

LEt a Planets declination be 26 degrees, its Latitude 4 degrees, and its distance from the nearest Equinoctial point 70 degrees, (it being in the 10 degree of *Gemini*) I demand the right ascension thereof, which to attain.

Set 64 deg. the Co-sine of the declination, to 20 deg. the Co-sine of the Planets distance from the next Equinoctial point; and then against 86 deg. on the first, the Co-sine of the Planets latitude, is 22 deg. 17 minutes on the second, the Co-sine of the right ascension: Therefore 67 deg. 43 min. (being the Complement of 22 deg, 17 min.) is the right ascension of that Planet which was demanded.

PROBLEM. XVII.

The Suns greatest declination, with his distance from the next Equinoctial point, being had; to find the Meridian angle, that is, the intersection of the Meridian with the Ecliptick.

LEt the Suns greatest declination be 23 deg. 30 min. and his place just entering *Taurus*,

which is distant from the nearest Equinoctial point 30 degrees, I would know the Meridian angle

Set the Radius on the first, to 60. degrees, the Co-sine of the Suns distance from the neerest Equinoctial point on the second, and then on the lines of Tangents, against 23 deg. 30 m. the Tangent of the Suns greatest declination on the first is 20 deg. 38 min, on the second, which is the Co-tangent of the angle sought: Wherefore the Meridian angle is 69 deg. 22 minutes, being the Complement of 20 degrees 38 minutes, to 90 degrees.

PROBLEM. XVIII.

The Suns declination and amplitude given; to find the height of the Pole.

LEt the Suns declination given be 14 degr. 51 min. and his amplitude 19 deg. 7 min. And the Poles elevation demanded.

Set 19 degr. 7 min. the amplitude on the first, to 14 deg. 51 min. the declination on the second; and then against the Radius on the first, is 51 deg. 30 min. on the second, which is the sine of the latitude: Wherefore 51 deg. 30 min. is the Latitude sought.

PRO-

PROBLEM. XIX.

The amplitude of the Sun, and time of his rising being known, to find thereby his declination.

Let the Suns amplitude be 33 degr. 38 min. and the time of his rising be at 4 a clock 10 minutes; by which two things known, I would find the declination of the Sun. Here first convert the 4 hours 10 minutes into degrees and minutes, and they make 62 degr. 30 minutes.

Now set the 62 degr. 30 min. the time of Sun-rising converted into degrees on the first to 56 deg. 22 min. the Co-sine of the amplitude on the second; and then against the Radius on the first, is 69 degr. 50 min. on the second, the Co-sine of the declination: Whereby it followeth, that 20 deg. 10 min. is the declination desired.

PROBLEM. XX.

Having the elevation of the Pole, and the Suns amplitude, to find his declination.

Let the Elevation of the Pole be 51 degr. 30 min. and the Suns amplitude 19 deg. 7 m. By which two things given, the declination is required.

Set the Radius on the firſt, to 19 deg. 7 min. the Suns amplitude on the ſecond, and then againſt 51 deg. 30 min. the ſine of the elevation on the firſt, is 14 deg. 51 min. the fine of the declination upon the ſecond: The thing deſired.

PROBLEM. XXI.

Having the hour of the day, the Suns altitude and declination; to find the Azimuth.

LEt the Suns altitude be 25 degr. 56 min. whoſe Complement is 64 deg. 4 min. his declination 11 deg. 30 min. whereof the Complement is 78 deg. 30 min. The hour of the day, 7 hours 56 minutes fore noon, which time is diſtant from noon 4 hours 4 minutes. This time converted into degrees, giveth 61 degrees. Now by theſe things known, the Azimuth is deſired to be found.

Set 64 degrees 4 minutes, the Co-fine of the Suns altitude on the firſt, to 61 degrees, the Suns diſtance from the Meridian on the ſecond: and then againſt 78 degrees 30 minutes the Co-fine of the declination on the firſt, is 72 degrees 22 minutes on the ſecond; So much is the Suns Azimuth from the South Eaſtwards.

PRO-

PROBLEM. XXII.

The Suns declination, altitude, and azimuth being known, to find the hour of the day.

SUppoſe the Suns declination be 11 degr. 30 min. his altitude 25 deg. 56 min. and the Azimuth 72 deg. 22 min. Hereby to find the hour of the day.

Set 78 deg. 30 min. on the firſt, (which is the Complement of the declination) to 64 deg. 4 min. on the ſecond, which is the Complement of the Altitude; and then againſt 72 deg. 22 min. the Azimuth on the firſt, is 61 degr. on the ſecond. This 61 degrees converted into time, giveth 4 hours 4 minutes, which taken from 12 hours, the Remain is 7 hours 56 minutes before noon, the time of the day required.

PROBLEM. XXIII.

The altitude of the Equator, and the Suns, or a Stars declination being given, to find the angle of the Meridian with the Horizon.

LEt the altitude of the Equator be 51 degrees 30 minutes, and the declination 22 degrees. And the angle of the Meridian with the Horizon ſought for.

Set

Set 68 degrees, the Co-ſine of the declin-tion on the firſt, to the Radius on the ſecond, and then againſt 51 deg. 30 min. the Co-ſine of the Equators altitude, on the firſt, is 57 degrees 34 minutes on the ſecond: So much is the angle of the Meridian (or circle of Declination) with the Horizon.

CHAP. IX.

The Uſe of the double Scales in Geography.

PROBLEM. I.

Two places lying without the Equinoctial, and having both one Latitude; differing onely in Longitude, being propounded; to find their Diſtance.

SUppoſe there be two places, lying both in the Latitude of 48 deg. 20 min. differing only in Longitude 16 degrees, as do *Paris* in *France*, and *Vienna* in *Auſtria*, whoſe diſtance is deſired.

Set the Radius on the firſt, to 41 degrees 40 minutes, the Co-ſine of the Latitude on the ſecond; and then againſt 16 degrees on the firſt, the difference of Longitude, is 10 degrees 36 minutes, which in miles makes 636: So much is the diſtance between the two places.

PRO-

PROBLEM. II.

The places being propounded, which differ in Longitude, the one lying under the Equinoctial and the other having Latitude, to find their distance in miles.

LEt two places be propounded, the one lying under the Equinoctial, having 313 deg. of Longitude, and the other lying in the Latitude of 32 deg. 42 min. and in the Longitude of 323 degrees, they differing in Longitude 10 degrees, I would know their distance.

Set the Radius on the first, to 80 degrees on the second, the Co-fine of the difference of Longitude; and then against 57 deg. 18 min. the Co-fine of the one places Latitude on the first, is 55 deg. 58 min. the Co-fine of the distance in degrees; the Complement of this 55 deg. 58 min. to 90, is 34 deg. 2 min. which converted into English miles, giveth 2042 miles: So much is the distance between the two places.

PROBLEM. III.

Two places having several Latitudes towards one Pole, and differing in Longitude; *to find their distance.*

LEt L*ondon* & *Jerusalem* be two places propounded, betwixt which the distance is required:

quired: The Latitude of *London* is 51 degrees 30 minutes, the Latitude of *Jerusalem* is 32 degrees; and their difference in Longitude is 47 degrees. Now to find their distance.

1 Set the Radius on the first, to 43 degrees the Co-sine of the difference of Longitude on the second; and then on the lines of Tangents against the Co-tangent of the greater Latitude, 38 degrees, 30 min. is 28 deg. 28 min. on the second; the fourth term. This fourth term, 28 deg. 28 min. taken out of the Complement of the lesser Latitude, that is here, out of 58 deg. the Remain is 29 deg. 32 min. Then,

2 Set 28 deg. 28 min. the fourth term found, to that Remain, 29 deg. 32 min. on the second, and then against the Co-sine of the greater Latitude, *viz.* 38 deg. 30 min. is the sine 39 deg. 14 min. the distance sought for in degrees of a great Circle, which converted into miles, makes 2354 miles, the distance between *London* and *Jerusalem*.

PROBLEM. IV.

Two places, one having North Latitude, and the other South Latitude, and differing in Longitude*, to find their distance.*

Suppose the one place be in 50 degrees of North Latitude, and the other in 32 degr. 25 min.

25 min. of South Latitude, and their difference in their Longitude 70 degrees, and betwixt these two such places, the distance is desired. To resolve this demand:

1 Set the Radius on the first, to 20 degrees the Co-sine of the difference of Longitude on the second; and then against 50 degrees, the Tangent of the greater Latitude, is the Tangent 16 degrees 1 minute, a fourth term. This fourth term, 16 degrees 1 minute, take from 57 degrees 35 minutes, the Complement of the lesser Latitude, and the Remain is 41 degrees 34 minutes, for a fifth term. Now then:

2 Set 73 degrees 59 minutes the Complement of 16 degrees 1 minute, the fourth term, to 48 degrees 26 minutes, the Complement, of that 41 degrees 34 minutes, the fifth term; and then against the sine, the greater Latitude 50 degrees on the first, is the sine 36 degrees 36 minutes, whose Co-sine 73 degrees 24 minutes, is the distance in degrees by a great Circle. This 53 deg. 24 min. being turned into miles, by multiplying by 60, maketh 3204 miles, and in leagues 1068: So much is the distance sought for between the two places.

CHAP.

CHAP. X.

Of plain right lined Triangles.

PROBLEM. I.

In a plain right lined Triangle, right angled, the three angles being known, and one side; to find either of the other sides.

IN the Triangle annexed A B D, let the angle at A be a right angle, or 90 degrees the angle at D. 43 deg. 20 min. and the angle at B. 46 deg. 40 min. and the side A B 230 yards; and let the side A D be the side sought.

The Resolution of this Problem upon the Instrument is by this Analogie:

As the Sine of the Angle opposite to the side known,
Is to the Sine of the Angle opposite to the side required:
So is the side known.
to the side sought.

And therefore in this Example it is,

As the sine 43 deg. 20 min. the angle at D opposite to A B the side known, is to the sine of the angle at B, 46 deg. 40 min. which is the angle opposite to the side sought A D: So is the

the length of the known ſide A B 230 yards, to 243 yards & very near three quarters of a yard, the length of the ſide A D, which was required. Wherefore,

Upon the lines of ſines, Set the ſine 43 deg. 20 min. on the firſt, (the angle at D. oppoſite to the ſide given.) To the ſine 46 deg. 40 min. on the ſecond, (which is the ſine of the angle oppoſite to the ſide required.) And then upon the lines of Numbers, againſt 230, the length in yards of the known ſide on that firſt, is 243 and three quarters very neer: So then the length of the ſide A D, which is ſought: is 243 yards, and very near three quarters.

For further illuſtration hereof; Suppoſe you were ſtanding at A, and would know how far it is from you to ſome notable mark, as to D. Here firſt erect ſome Mathematical Inſtrument, as the *Theodilit*, or ſome other at A, the place of your ſtanding; and by help thereof, let a mark be ſet up ſide-wayes, (which way the ground will be left for the purpoſe) as at B, in a line making right angles with the viſual line from you at A to D; this done, meaſure from A to your mark B, and find it 230 yards. Then place your Inſtrument at B, and obſerve the angle there as A B D, which find 46 deg. 40 m. this angle had, & the other at B being a right angle, the angle at the mark D muſt needs

be

be 43 deg. 20 min. being the Complement of the angle obſerved at B to 90 degrees: Theſe things had, the work by my Inſtrument is the ſame, as is afore ſhewed. For,

Set 43 deg. 20 min. on the firſt, to 46 deg. 40 min. on the ſecond; and then upon the lines of Numbers, againſt the meaſured length 230 on the firſt, is 243,7 & better on the ſecond: So then the diſtance from you to the mark is 243 yards, and ſomething better than ſeven tenths of a yard, which is very near 3 quarters. If you pleaſe to work this Example by the Tables of Logarithms, you ſhall find the work of the Inſtrument to agree moſt notably with that of the Tables.

I might have placed the Problems of right lined Triangles after thoſe of Spherical; for that theſe require to be reſolved by the lines of Sines, Tangents and Numbers together, whereas thoſe of Spherical Triangles are reſolved only by lines of Sines and Tangents alone, and therefore require the more variety: but the doctrine of plain Triangles being uſually firſt taught, I have therefore firſt placed it; and the rather, becauſe by theſe Problems of right lined Triangles, you may ſee the way to work with both the lines of Numbers, Sines, and Tangents altogether, in any caſe whatſoever.

PRO-

PROBLEM. II.

In a plain right lined Triangle oblique angled, the three angles and one ſide being known, to find either of the other ſides.

IN the Triangle C B D, let the obtuſe angle at C be 112 deg. 0 min. the angle at D be 43 deg. 20. min. and the angle at B 14 degr. 40 min. and let the known ſide be C D 100 pole, and let the ſide C B be the ſide ſought.

The Analogy for reſolution of the preſent Problem, is the ſame as in the former, wherefore it is ;

As 14 deg. 40 min. the angle oppoſite to the ſide known,
Is to 43 deg. 20 min. the angle oppoſite to the ſide ſought ;
So is 100, the length of the ſide known,
To 271 the length of that ſide ſought.

Therefore, upon the lines of Sines, Set the ſine 14 deg. 40 min. on the firſt, to 43 deg. 20 min. the ſine of the angle oppoſite to the ſide required on the ſecond ; and then upon the lines of Numbers, againſt 100 on the firſt, is 271 on the ſecond : So much is the length of that ſide ſought. For a further illuſtration :

Suppoſe you were ſtanding at C, and deſired to know how far it is from you to B. Hereby

by reaſon of ſome impediment, as a pond, a wall, a hedge, or ſome other thing, you cannot point out your ſecond ſtation at right angles with the viſual line from C to B, but are inforced to work by an angle greater than a right angle; wherefore at C obſerve an angle, as BCD of 122 degrees, and meaſure along from C to D 100 pole, and at D obſerve the angle CDB 43 deg. 20 min. Theſe two angles had, add them together, and they make 165 degr. 20 min. which taken from 180 degrees, leaveth 14 deg. 40 min. for the angle at B. (For in all Triangles, if any two of the angles be known, the third is alſo known, for it is evermore the Complement of them both to 180 degrees.) Theſe things thus had, the Analogy for reſolution of the *quære* by the lines, is the ſame as before. Therefore,

Set the ſine 14 deg. 40 min. on the firſt, (the ſine of the angle oppoſite to the ſide known) to the ſine 43 degr. 20 min. (the ſine of the angle oppoſite to the ſide required) on the ſecond; and then on the lines of Numbers, againſt 100, the length of the ſide known on the firſt, is 271 on the ſecond: Therefore 271 pole is the length, or diſtance of B, the mark from your ſtation C, which was deſired.

PRO-

PROBLEM. III.

If two sides of a right lined Triangle, and an Angle opposite to one of them sides being known; to find the angle opposite to the other side.

HEre the Analogy standeth thus by the Lines.

As that side opposite to the angle known,
Is to the other known side;
So is the known angle,
To that angle sought.

Example. In the Triangle B C D, let the one side known be the side C D, 100 yards; and the other side known be C B, 271 yards; and let the angle at B. be known to be 14 deg. 40 min. and let the angle at D be sought.

Upon the lines of Numbers; Set 100, the side C D opposite to the known angle B on the first, to 271 the side CB opposite to that angle at D sought for one the second; and then on the lines of Sines, against the sine of the known angle 14 deg. 40 min. on the first, is 43 degr. 20 min. on the second: So much is the quantity of the angle D, which was sought.

PROBLEM. IV.

Two ſides, and the angle included between them, being a right angle, to find the other two angles.

IF you would find the leſſer of the two unknown angles; Then the Analogy is,

As the greater ſide is to the leſſer,

So is the Radius to the Tangent of the leſſer angle.

Example. In the Triangle A B C, let there be known the ſide AB 230 yards, and the ſide A C 143 and three quarters very near, and the included angle juſt 90 degrees; and let the angle B, being the leſſer angle, be ſought; the which to find,

Upon the lines of Numbers, Set 230, the greater ſide known on the firſt, to 143 & three quarters, the leſſer ſide on the ſecond; and then upon the lines of Tangents, againſt the Radius on the firſt, is the Tangent 32 degr. 0 min. on the ſecond: So much is the quantity of the leſſer angle, which is the angle at B; and the Complement of that to 90, is 58 degrees: So much is the quantity of the angle C, being the greater of the two angles ſought.

If you wonld find the greater angle firſt, of the two unknown angles, then the Analogy is thus:

As

As the leſſer ſide, is to the greater,

So is the Radius, to the Tangent of the greater angle. Therefore,

Upon the lines of Numbers, Set the leſſer ſide known AC, 143 and three quarters on the firſt, to the greater ſide AB 230 on the ſecond and then on the lines of Tangents, againſt the Radius on the firſt, is the Tangent 58 degrees on the ſecond: So much is the quantity of the greater angle at C, & the Co-tangent thereof is 32 deg. So much is the quantity of the leſſer angle. For it is to be noted, that alwayes the greater angle is oppoſite to the greater ſide, and the leſſer angle is oppoſite to the leſſer ſide.

PROBLEM V.

In any oblique angled Triangle, whether obtuſe or acute, having two ſides, and the angle included between them, to find the other angles.

IN the Triangle BCD, let the angle known be the obtuſe angle at C 122 degres, & the two ſides including that angle, be C B the greater ſide, containing 271; & C D the leſſer ſide, containing 100, (which ſides may be reckoned poles, yards, feet, inches, or what other meaſure you pleaſe) and let the two angles at B and D be ſought.

In this caſe the Analogie will be thus:

As the ſum of the two ſides known,
Is to the difference betwixt the ſame ſides;
So is the Tangent of the half ſum of the two angles ſought,
To the Tangent of the half of their difference.

Here the two ſides including the known angle: are 100 and 271, which added together, their ſum is 371, for the firſt number in the rule of Proportion. Next take the leſſer ſide 100, from 271 the greater ſide, and the Remainder is 171, this is the difference between the ſides, and is the ſecond number in the rule: And then take the known angle 122 degrees from 180 degrees, or two right angles, and the Remainder is 58 degrees: So much is the quantity of both the other two angles at B & C, whereof the half is 29 degrees, this half ſum is the third number in the rule of Proportion: Theſe things had, then according to the Rule it is thus:

As 371 is to 171, So is the Tangent 29 deg. To the Tangent 14 deg. 20 min. Therefore,

Upon the lines of Numbers, Set 371 the ſum of the two containing ſides on the firſt, to 171 the difference of the ſame ſides on the ſecond; and then upon the lines of Tangents, againſt 29 degrees, the half ſum of the two angles ſought on the firſt, is the Tangent 14 deg,

deg. 20 min. on the ſecond. This 14 degr. 20 min. thus found, is the half of the difference of two angles ſought; therefore, To 29 degr. the half ſum of the angles ſought, add this 14 deg. 20 min. & the ſum is 43 degr. 20 min. So much is the quantity of the angle at D, the greater of the two angles ſought; and this 14 deg. 20 min. taken out of that 29 degr. 0 min. the Remainder is 14 deg. 40 min. So much is the angle B, the leſſer of the two angles ſought.

PROBLEM. VI.

In any right lined Triangle, whether right angled or oblique angled, any two ſides being known, with the angle included between them, to find the third ſide.

IN the oblique angled Triangle CBD, Suppoſe you have the two ſides given CD 100 yards, and C B 271 yards, and the angle C included betwixt them 122 degr. and you require to know the ſide DB oppoſite to the obtuſe angle C. Here firſt you muſt by the laſt Problem find out the two angles unknown, and then having the three angles and two ſides known, you may by the angles and on the ſides find the third ſide, according to the ſecond Problem: As ſuppoſe you would chooſe the ſide CD 100, and thereby work to

find the ſide D B. Then the proportion will ſtand thus:

As 14 deg.40 min.the ſine of the angle oppoſite to the choſen ſide,
Is to 58 deg. the Complement of 122 deg. the angle C oppoſite to the ſide ſought:
So is 100,the length of the choſen ſide CD,
To 335, the length of that ſide D B,which is required.

Therefore upon the lines of Sines, Set 14 deg.40 min. the ſine of the angle appoſite to the choſen ſide on the firſt,to the ſine 58 deg. the Complement of 122 deg.to 180;and then upon the lines of Numbers, againſt 100, the length of the ſide choſen on the firſt,is 335 on the ſecond:So many yards is the length of the ſide D B, which was required.

Again,Suppoſe in the right angled Triangle B A C, right angled at A you have the two ſides A B 230, and the ſide AC 143 and near three quarters,and the included angle 90 degrees.Then to find the other two angles,work as in the laſt Problem thus:Add the two ſides together,230 and 143 and three quarters,and the ſum is 373 and three quarters,for the firſt number. Then take the leſſer ſide, 143 and three quarters,out of 320 the greater ſide,and the Remainder is 86, and one fourth for the ſecond number, and the angle A is the third number

number in the rule of Proportion. Therefore,

Set 373 and three fourths, the ſum of the ſides on the firſt, to 86 and one fourth, their difference on the ſecond, and then againſt the Tang. 45 deg. the half ſum of the two angles ſought on the firſt, is the Tang. 13 deg. on the ſecond, theſe deg. added to the 45 deg. and the ſum is 58 deg. for the greateſt of the two angles ſought: And taken from 45 deg. leaveth 32 deg. for the leſſer of them two angles.

The angles thus had, to find the third ſide C B. Set 32 deg. on the firſt, to 90 on the ſecond, and then againſt 143 and three fourths on the firſt, (the ſide choſen to work by) is 271 on the ſecond: So much is the length of the ſide C B, which is required.

Or elſe, making uſe of the ſide A B, Set the ſine 58 deg. to 90; and then on the lines of numbers, againſt 320 on the firſt, is 271 on the ſecond: The length of the ſide ſought, as before,

PROBLEM. VII.

In a right lined Triangle, the three ſides only being known; to find the Perpendicular, and thereby the three angles.

LEt the greateſt of the three ſides of your Triangle be taken for the Baſe, for ſo the

Perpen-

Perpendicular will fall within the Triangle; then take the ſum of the two ſides by adding them together, and alſo their difference, by ſubſtracting the leſſer from the greater: As in the Triangle C B D, make D B the Baſe, being the longer ſide 335 foot, and the other two ſides be C D 100, and C B 271, theſe two ſides added together make 371, and the leſſer being ſubſtracted from the greater, their difference is 171. Theſe had, the Proportion is thus:

As the Baſe D B 335,
is to the ſum of the two ſides 371,
So is the difference of the two ſides 171,
to a fourth ſum. Therefore,

Upon the lines of Numbers onely, Set 335, the length of the Baſe on the firſt, to 371 the ſum of the ſides on the ſecond; and then againſt 171, the difference of the ſides on the firſt, is 189,4 on the ſecond; this 189,4 taken out from the Baſe 335,0, and the Remainder is 145, 6 the half whereof is 72, 8: So many foot meaſured in the line D B, from D towards B, (becauſe the angle at D is the greateſt of the two angles at the Baſe) will reach to E, the point where the Perpendicular C E will cut the Baſe D B. By which Perpendicular, the Triangle C D B, is divided into two right angled Triangles, D E C and C E B, which

which being done, all the other angles may be found by the third Problem of this Chapter: For here you have two ſides D C 100, and D E 72,8, and the right angle D E C oppoſite to the ſide D C. Therefore by that third Problem, to find the angle E C D.

Set 100, the ſide oppoſite to the angle known on the firſt, to 72,8 the ſide oppoſite to the angle ſought on the ſecond; and then on the lines of ſines againſt 90 degr. the angle known is 46 degr. 40 minutes. So much is the quantity of the angle E C D, and its Complement to 90 is 43 deg. 20 min. for the quantity of the angle C D E. Thus have you the three angles of the right angled Triangle D E C. And for the length of the Perpendicular, it is thus attained unto by the firſt Problem. For,

Set 46 deg. 40 min. the quantity of the angle C, oppoſite to the known ſide E D on the firſt, to 43 deg. 20 min. the angle D oppoſite to the Perpendicular E C: and then on the lines of Numbers, againſt 72, 8 the length of the ſide known on the firſt, is 68,5 and ſomething more: So much is the length of the Perpendicular E C, which was required.

In like manner, as the Angles and Perpendicular in this right angled Triangle are found even ſo are found the Angles in that other right angled Triangle C E B on the other ſide

of

of the Perpendicular; for you shall find the angle E B C 14 deg. 40 min. the angle B C E 75 deg. 20 min. And in conclusion, you shall find that the two angles at C, made by the Perpendicular, namely E C D and ECB will make just 122 degrees, which was the quantity of the obtuse angle at C, before the Perpendicular was drawn.

PROBLEM. VIII.

In a right angled Triangle, the Angles and the Hypothenusal being given, to find any one of the sides including the right angle.

IN the right angled Triangle B A C, let the angles known be as afore, at C 58 deg. and at B 32 deg. and the angle at A a right angle, and the Hypothenusal C B be 271 yards; and you would hereby find the sides A C & A B, which for to do, the rule is thus by the lines on my Scale.

As the Radius, is to the angle opposite to the side sought;
So is the Hypothenusal or side opposite to the right angle, to that side sought.

Therefore to find the side A C.

Set the Radius on the first, to 32 deg. on th second, which is the angle opposite to the side sought; and then, on the lines of Numbers, against

against271 the side known on the first is 143 and three quarters very near on the second: So many foot is the length of the side A C.

and for the side A B.

Set the Radius on the first to 58 deg. on the second, (which is the angle opposite to A, B, the side sought;) and then on the lines of Numbers, against 271 the Hypothenusal on the first 230 on the second: So many foot is the length of the side A B.

Now for your further instruction; Let it be supposed, that A B is the altitude of some body, as a Tree, a Turret, a Steeple, or the like, which you would know, & can come no nearer to it than at C; therefore at C take the angle of altitude B C A 58 degrees, and then the angle at B the top of the altitude, made by the visual line C B, and the altitude A B will be 32 deg. being the Complement of the observed angle to 90 deg. for the altitude is supposed to stand perpendicular, and to make a right angle at the base A. Then from C, measure backwards in a right line 100 yards to D, and there observe the angle of altitude BDA, and find it 43 deg, 20 min. These two angles thus observed keep, and take the first observed angle at C 58 deg. out of 180 deg. & the Remainder is 122 deg. which is the quantity of the obtuse angle BCD made by the stationary line

line C D, and the viſual line C B. This angle of 122 deg.& the angle obſerved at D 43 deg. 20 min. add together and they make 165 deg. 20 min. which taken from 180 degr. the Remainder is 14 degr. 40 min. So much is the angle at B, the top made by the two viſual lines CB and DB. Thus having attained the three angles of a Triangle C B D, and one ſide being the ſtationary diſtance, you may find the ſide or Hypothenuſal CB, by the ſecond Problem, and with the Hypothenuſal, the altitude by this Problem.

CHAP.

CHAP. XI.

Of Trigonometrie, ſhewing the uſe of the double Scale, of Numbers, Sines and Tangents, in the reſolution of Triangles, either plain or ſpherical.

PROBLEM. I.

The two ſides of a rectangle Triangle being given to find the Baſe, which is the ſide oppoſite to the right angle.

IN the Triangle ABC of the annexed Diagram, Let the ſide AC be 27 deg, 45 min. and the ſide CB 11 deg. 30 min. be given, and the baſe A B required,

For reſolution of this *quære*, ſay thus:

As the Radius is to the Co-ſine of one of the given ſides; So is the Co-ſine of the other given ſide to the Co-ſine of the baſe. Therefore,

Set the Radius on the firſt, to 62 deg. 6 min. the Co-ſine of the one ſide given, *viz.* of A C 27 deg. 54 min. on the ſecond; and then againſt the Co-ſine of B C, 11 degr. 30 min. which is 70 deg. 30 min. on the firſt, is 60 deg. the

the Co-ſine of the ſide or baſe required : So then the baſe A B is 30 degrees.

PROBLEM. II.

The two ſides being given, to find either of the oblique angles.

IN the Triangle ABC aforementioned; Let A C be given 27 deg. 45 min, and B C 11 deg. 30 min. and let the angle A, next the ſide A C, be ſought. Say,

As the ſine of the ſide next the angle ſought, is to the Radius; So is the Tangent of the ſide oppoſite to the angle ſought, to the Tangent of the ſame angle. Therefore,

Set 27 deg. 54 min. the ſide adjacent to the angle ſought, to the Radius on the ſecond; and then againſt the Tangent of 11 deg. 30 min. the ſide oppoſite to the angle ſought on the firſt, is the Tangent 23 deg. 30 min. on the ſecond : So much is the angle at A, that was required.

If the angle ſought for do appear to be above 45 deg. as doth the angle *B*, and the ſides leſſe than 45 deg. then the beſt way to find *B*, is by the next Problem to find the baſe, and then having the baſe to find the angle *B*.

*B*ut if the ſide oppoſite to the angle ſought be above 45 degrees, as ſuppoſe the ſides A C were

were 61 deg,53 min.and C B 54 deg.28 min. and the angle A ſought for. Then work thus.

Set the Radius on the firſt,to the ſine of the ſide adjacent to the angle ſought, *viz.* to the ſine of A C 61 degr. 53 min. on the ſecond; and then againſt the tangent 54 degr.28 min. the ſide oppoſite to the angle ſought on that firſt, is 57 degr. 47 min. the Tangent of the angle A ſought for. Here note, that in examples of this kind the angle found is greater then 45 degrees.

PROBLEM. III.

One ſide, and the oblique angle next unto it being given; to find the Baſe.

LEt the ſide A C 27 degr.54 min. and the angle A 23 deg.30 min.be given,and the Baſe A B ſought.

As the Co-ſine of the angle given,
is to the Radius;
So is the tangent of the ſide given,
to the tangent of the baſe. Therefore,

Set 66 deg. 30 min. the Co-ſine of the angle given, to the Radius,and then againſt the tangent 27 deg.54 min.on the firſt,is the tangent 30 deg. on the ſecond, the baſe ſought.

If the ſide given be above 45 degrees,as were the ſide A C,61 deg.53 min.and the angle A

57 deg.47 min. then to find the baſe; Set the Radius to 32 degr.13 min.the Co-ſine of the angle given,and then againſt the tangent of the ſide 61 degr. 53 min. is the tangent 74 degr. 6 min. for the baſe A B.

PROBLEM. IV.

The Baſe,and one of the oblique angles being given; to find the other oblique angle.

IN the Triangle aforeſaid;Let there be given the Baſe 30 degrees, and the oblique angle A 23 deg.30 min.and the angle B required.Say,

As the Radius,is to the Co-ſine of the Baſe;
So is the Tangent of the angle given, to
the Co-tangent of the angle required.

Therefore,

Set the Radius on the firſt, to 60 degr.the Co-ſine of the Baſe; and then againſt 23 deg. 30 min.the tangent of the angle given, is the tangent 20 deg. 38 min. which is the Co-tangent of the angle B. Wherefore the ſaid angle is 69 deg. 22 min.

If the angle given be above 45 degrees;As if the angle given be the angle B,and the leſſer angle A ſought, then, Set the Co-ſine of A B 60 degrees on the ſecond to the Radius; and then againſt the tangent of the given angle 69 degrees 22 minutes on that firſt, is

23 de-

23 degrees 30 minutes, the Tangent of the Angle **A**.

PROBLEM. V.

The Base, and one of the oblique angles given: to find the side next the same angle.

LEt the Base A B 30 degr. and the angle A 23 deg. 30 min. be given, and let the side AC adjacent to the angle A be required. Say,

As the Radius, to the Co-sine of the angle given;
So is the tangent of the base, to the tangent of the side sought. Therefore,

Set the Radius on the first, to 66 degr. 30 min. the Co-sine of the angle given on the second; and then against the tangent of the base 30 degrees, is the tangent of the side sought, 27 deg. 54 min.

If the base be above 45 degrees: as, Let the base AB be 74 deg. 6 min. and the angle A 57 deg. 47 min, and then to find the base.

Set 33 degr. 13 min. the Co-sine of the angle given on the first, to the Radius on the second; and then against the tangent of the base 74 deg. 7 min. on the first, is 61 degr. 53 min. the side **A C** sought for.

PROBLEM. VI.

The Baſe, and one of the oblique angles given: to find the ſide oppoſite to the angle given?

LEt the Baſe A B 30 degrees, and the angle A 23 degrees 30 minutes be given, and let the ſide C B oppoſite to the ſame angle A be ſought.

As the Radius, to the Sine of the Baſe;
So is the Sine of the angle given, to the Sine of the ſide ſought. Therefore,

Set the Radius on the firſt, to 30 degrees, the Sine of the Baſe on the ſecond; and then againſt 23 deg, 30 min. on the firſt is 11 degr. 30 min. on the ſecond, the ſide C B, which was ſought for.

PROBLEM. VII.

One ſide, and the oblique angle next it being given; to find the other ſide.

LEt the ſide A C, 27 degr. 54 min. and the angle A 23 deg. 30 min. be given, and the ſide B C required. Say,

As the Radius, to the Sine of the ſide known;
So is the tangent of the angle known, to the tangent of the ſide required. Therefore.

Set

Set the Radius on the firſt, to 27 degr. 54 minutes, the ſine of the ſide known; and then againſt the tangent of the angle A, 23 degrees 30 min. on the firſt, is the Tangent 11 degr. 30 minutes for the ſide C B, which was required.

PROBLEM. VIII.

One ſide, and the oblique angle next it being known; to find the other oblique angle.

LEt the ſide A C, 27 degr. 54 min. and the angle A 23 deg. 30 min. be given, and the angle B ſought. Say,

As the Radius, to the Co-ſine of the ſide given;

So is the Sine of the angle given, to the Co-ſine of the angle ſought. Therefore,

Set the Radius on the firſt, to 62 deg. 6 min, the Co-ſine of 27 degr. 54 min. the ſide given; and then againſt the Sine of the angle given, 23 deg. 30 min. is the Sine 20 deg. 38 min. the Complement of 69 degr. 22 min. the angle B, which was required.

PROBLEM. IX.

One side, and the angle opposite to it being known; to find the Base.

LEt the side B C 11 deg. 30 min. and the angle A 23 deg. 30 min. be given, and let the Base A B be sought for. Say,

As the sine of the angle given, to the sine of the side given;
So is the Radius to the sine of the base.

Therefore,

Set 23 deg. 30 min. the sine of the angle given on the first, to 11 deg. 30 min. the sine of the side given; and then against the Radius on the first, is the sine 30 deg. on the second. Therefore 30 deg. is the base sought for.

PRO LEM. X.

One side, and the angle opposite to it being given; to find the other side.

LEt the side B C 11 deg. 30 min. and the angle A 23 deg. 30 min. be given, and the side A C sought for. Say,

As the Tangent of the angle given, is to the Tangent of the side given;
So is the Radius, to the sine of the other side. Therefore,

Set

Set the Tangent of the angle A, 23 degr. 30 min. on the first, to the Tangent of 11 deg. 30 min. on the second; and then against the Radius on the first, is 27 deg. 54 min. The sine of the side A C, sought for.

Sometime it so falleth out in this Problem and some others, by reason of a great angle or side, that the resolution cannot be readily done by the Analogy set down; yet you shall see ready wayes upon the lines to perform the same, or by other Problems to gain the thing sought.

PROBLEM. XI.

One side, and the angle opposite to it being known; to find the other angle.

LEt the side C B 11 deg. 30 min. and the angle A 23 deg. 30 min. be given, and the angle B sought. Say,

As the Co-sine of the side given, to the Co-sine of the angle given;

So is the Radius, to the sine of the angle required. Therefore,

Set 78 deg. 30 min. the Co-sine of the side C B given on the first, to 66 deg. 30 min. the Co-sine of A the angle given; and then against the Radius on the first, is 69 deg. 22 min. on the second. The sine of the angle sought.

PROBLEM. XII.

The Base, and one side known; to find the oblique angle adjoyning to the same side.

LEt the side A C, 27 degr. 54 min. and the Base A B 30 degrees, be given, and the angle A adjoyning to the side given, sought for.

Say,

As the tangent of the Base, to the tangent of the side given;

So is the Radius, to the Co-sine of the angle required. Therefore,

Set the tangent of the Base 30 degr. on the first, to 27 degr. 54 min. the tangent of A C, the side given on the second; and then against the Radius on the first, is 66 degr. 30 min. on the second, whose Co-sine is 23 degr. 30 min. The sine of the angle A that was sought.

When the Base and side be above 45 degr. as, Suppose the Base A B to be 74 deg. 6 min. and the side A C 61 deg. 53 min. then set the tangent of that side next the angle sought, *viz.* 61 deg. 53 min. on the first, to the tangent of the Base 74 deg. 6 min. on the second; and then against the Radius on the first, is 23 degr. 13 min. the Co-sine of the angle A. After this manner, by altering the placing of the terms given, one way or other, any *quære* may be resolved.

PRO-

PROBLEM. XIII.

The Baſe, and one ſide being given; to find the angle oppoſite to the ſame ſide.

LEt the ſide AC, 27 deg. 54 min. and the Baſe A B 30 deg. be given, and the angle B required. Say,

As the ſine of the Baſe, to the Radius.

So is the ſine of the ſide given, to the ſine of the angle required.

Set 30 deg. the ſine of the Baſe on the firſt, to the Radius on the ſecond; and then againſt 27 deg. 54 min. the ſine of A C the ſide given on the firſt, is 69 deg. 22 min. The ſine of the angle B, which was required.

PROBLEM. XIV.

The Baſe, and one ſide being given; to find the other ſide.

LEt the ſide A C 27 deg. 54 min. and the Baſe A B 30 degr. be given, and the ſide C B ſought for. Say,

As the Co-ſine of the ſide given, to the Radius; So is the Co-ſine of the Baſe, to the Co-ſine of the ſide ſought. Therefore,

Set 62 deg, 6 min. the Co-ſine of the ſide given, to the Radius; and then againſt 60 degr the

the Co-ſine of the Baſe, is 78 deg. 30 min. the Co-ſine of the ſide **B C**, **11** degr. 30 min. that was required.

PROBLEM. XV.

The two oblique Angles being given, to find the Baſe.

LEt the angle A be 23 deg. 30 min. and the angle B 69. 22 min. be given, and let the Baſe A B be ſought.

As the tangent of one of the angles, is is to the Co-tangent of the other angle;
So is the Radius, to the Co-ſine of the Baſe. Therefore,

Set the tangent of the one angle, as of that at A 23 degr. 30 min. on the firſt, to the Co-tangent of the other angle, *viz.* to 20 degr. 38 min. on the ſecond; and then againſt the Radius on the firſt, is the ſine 60 degrees on the ſecond. Which is the Co-ſine of 30 degrees, the Baſe A B, which was required.

PROBLEM. XVI.

The two oblique angles being given; to find either of the ſides.

LEt the angle A be 23 degr. 30 min. & the angle B 69 deg. 22 m. and let the ſide A C be ſought. Say,

As

As the ſine of one of the angles, is to the Co-ſine of the other angle;

So is the Radius, to the Co-ſine of the ſide oppoſite to that angle, whoſe Co-ſine was taken. Therefore.

Set the ſine of the angle A 23 deg. 30 min. on the firſt, to 20 deg.38 min.the Co-ſine of the other angle B 69 deg.22 min. And then againſt the Radius, is 62 degr. 6 min. which is the Co-ſine of 27 deg. 54 min.the ſine of the ſide AC ſought. Having ſhewed the uſe of the double lines, through all the varieties of right angled Spherical Triangles, I come to the Oblique.

In Oblique angled ſpherical Triangles

PROBLEM. XVII.

Two angles, and a ſide oppoſite to one of them being given; to find the ſide oppoſite to the other.

LEt the Triangle propoſed be ABE, wherein let be given the angle E.38deg.15 min. and the ſide A B 30 degrees, and the angle A 23 deg. 30 minutes, and let the ſide B E be ſought. Say,

As

As the Sine of the angle oppoſite to the ſide known, is to the Sine of the ſame ſide,
So is the Sine of the angle oppoſite to the ſide ſought, to the Sine of that ſame ſide.
Therefore,

Set 38 deg. 15 min. the ſine of the angle E, to the Sine of the ſide given 30 deg. (*viz.* A B) And then againſt 23 degr. 30 min. the Sine of the other angle A on the firſt, is 18 degr. 47 min. The Sine of B E, the ſide ſought.

PROBLEM. XVIII.

Two ſides, and an angle oppoſite to one of them being known; to find the angle oppoſite to the other of them.

IN the Triangle A B E, let the ſide A B be 30 deg. the angle E 38 degr. 15 min. and the ſide B E 18 deg. 47 min, and let the angle A, which is the angle oppoſite to the ſide B E. be ſought. Say,

As the Sine of the ſide oppoſite to the angle given, is to the Sine of the ſame angle;
So is the Sine of the ſide oppoſite to the angle ſought, to the Sine of that ſame angle
Therefore,

Set 30 degrees, the ſide A B on the firſt, to 38 deg. 15 min. the Sine of its oppoſite angle on the ſecond; and then againſt 18 deg. 47 min. the

the ſine of B E the other ſide, is 23 degr. 30 min. the ſine of A its oppoſite angle, which is the thing that was to be ſought.

PROBLEM. XIX.

Two ſides, and the angle included between them being known; to find the other ſide oppoſite to that angle.

IN the Triangle A B E, let the ſides A B 30 deg. and A E, 42 deg. 51 min. with the angle A included between them, be given, and the ſide B E required.

Here firſt a Perpendicular muſt be ſuppoſed to be let fall from the unknown angle B, to the ſide A E oppoſite to that angle, & now to find on what part of the ſide A E it will fall. Say,

As the Radius, to the Co-ſine of the included angle A;
So is the Tangent of A B, to the Tangent of A C. Therefore,

Set the Radius on the firſt, to 66 deg. 30 min: the Co-ſine of the included angle A; and then againſt the Tangent of A B 30 degrees the leſſer ſide, is 27 degrees 54 minutes, the Tangent of the diſtance from A to C, on the ſide A E; therefore C is the point whereon the Perpendicular will fall. This diſtance A C 27 deg. 47 min. deduct out of the whole ſide A E

42 deg.

42 deg. 51 min. And the Remainder is 14 deg. 57 min. Then say,

As the Co-sine of A C, the distance found,
Is to the Co-sine of C E, the Remainder;
So is the Co-sine of A B, the lesser side, to the Co-sine of B E, the side required.

Therefore.

Set 62 deg. 6 min. the Co-sine of A C, the distance found, 75 degr. 3 min. the Co-sine of C E, the Remainder; and then against 60 degrees, the Co-sine of the side A B. is 71 deg. 13 min. the Co-sine of B E, 18 deg. 47 min. the side required.

It is to be observed that in oblique angled Triangles, when the terms propounded are two sides and one angle, or two angles & one side, and yet not resolveable by the two last Problems before this: That then a Perpendicular is to be let fall, (or supposed to be let fall, from one of the unknown angles, to the side opposite thereto; and so of the oblique angled Triangle given, to make two right angled Triangles. Which being done, all the parts of such a Sphericial Triangle, may be found out by the former Problems of right angled Triangles. This perpendicular will sometime fall within the Triangle, and that is, when the angles at the ends of the side whereon the Perpendicular fals, are both of one kind, that is to say,

ſay, both acute, or both obtuſe; as in the Triangle A B E. And ſometime this perpendicular fals without the Triangle, and that is, when the angles at the ends of the ſide whereon it fals, are of differing kinds; that is, one acute, & the other obtuſe, as in the Triangle A D B, where the Perpendicular B C falls on the ſide A D, it being prolonged, as it muſt always be in thoſe caſes.

PROBLEM. XX.

Two ſides with the angle included between them, being given; to find either of the other angles.

Let the ſides AB 30 degr. and AE 42 degr. 51 min. with the angle A 23 degr. 30 min. be given, and the angle E ſought.

As in the laſt Problem, ſo here a Perpendicular muſt be let fall on the given ſide A E, from its oppoſite angle B, and ſo of the oblique angled Triangle, make two rectangled Triangles. This Perpendicular, as afore was ſhewed, is thus found: Set the Radius to 66 degr. 30 min. the Co-ſine of the included angle; and then againſt the Tangent of 30 deg. the further ſide, is the Tangent 27 deg. 54 min. So much is the part of the ſide A E, betwixt A and the point C, where the Perdendicular falleth. Now if 27 degr. 54 min. be taken from

42 deg.

42 deg.51 min.the Remain is 14 deg, 57 min for the ſide of the rectangled Triangle B C E. Now to find the angle E,the Analogie is thus.

As the ſine of the ſide C E,is to the ſine of the ſide A C; So is the Tangent of the angle included, to the Tangent of the angle ſought.

And therefore.

Set the ſine of CE, 14 deg. 57 min.one the firſt, to the ſine of A C, 27 degr. 54 min.the part found; and then againſt the Tangent of A, 23 deg.30 min.is the tangent 38 degr. 15 min.the Angle E that was ſought.

Otherwiſe,having let fall the Perpendicular:and having found C E,14 deg.57 min. together with the Baſe 18 degr.47 min. then to find E, work as by the 12 Problem of rectangled Spherical Triangles,in this manner.

Set the Tangent of the Baſe, 18 degr. 47 min. to the Tangent of that part of the ſide C E; 14 degr. 57 min. And then againſt the Radius on the firſt.is 38 degr. 15 min. the ſine of the angle E,as before. In this manner may any of the other terms be alſo found out, by one or other of thoſe Problems.

PRO-

PROBLEM. XXI.

Two ſides, and one angle next to the ſide ſought being given; to find the ſame ſide.

LEt the ſides AB 30 degr. and BE 18 degr. 57 min. and the angle A 23 deg. 30 min be given and the ſide AE required. Here firſt let fall the perpendicular B C, and ſay,

As 60 deg. the Co-ſine of AB, is to 71 deg. 13 min. the Co-ſine of B E, 18 degr. 47 min.

So is the Co-ſine of A C 27 degr. 54 min. *viz.* 62 deg. 6 min. to 75 degr. 3 min. the Co-ſine of C E. Therefore,

Set 60 deg. the Co-ſine of AB, to 71 degr. 13 min. the Co-ſine of B E; and then againſt 62 deg. 6 min. the Co-ſine of AC, is 14 degr. 3 min. the Co-ſine of C E. wherefore C E is 14 degr. 57 min. which added to A C 27 degr. 54 min. makes 42 degr. 51 min. for the ſide A E, which was ſought.

M PRO-

PROBLEM. XXII.

Two sides, and an angle adjacent to one of them being given, to find the angle included between the same sides.

LEt the sides given be AB, 30 degrees, and B E 18 degr. 47 min. with the angle A 23 deg. 30 min. and let the obtuse angle B included betwixt the two sides, B A, and B E, be required: To resolve this demand, Say,

1 As the Radius, to the Co-sine of A B; So is the Tangent of the angle A, to the Tangent of a B c.

2 As the tangent of B E, to the Tangent of A B; So is the Co-sine of a B c, to the Co-sine of c B e. Therefore,

1 Set the Radius, to 66 degrees, the Co-sine of A B, and then against the Tangent of A 23 degr. 30 min. is the Tangent 69 degr. 22 min. the angle a B c, made by letting fall the perpendicular, and is part of the angle a B e sought. Now to find the Remainder.

1 Set 18 degr. 47 min. the Tangent of B E on the first, to the Tangent of A B 30 degrees, and then against the Co-sine of a B c, which is 20 deg. 38 min. is 36 deg. 46 min. whose Complement 48 degr. 14 min. is the angle c B e, which

which added to 69 degr.22 min. makes 122 deg.36 min. the angle ABE, which is the thing required.

PROBLEM XXIII.

Two angles, with the side lying betwixt them being known; to find either of the other sides.

LEt be given the angles A 23 degr.30 min. and B 122 degr.36 min. and the side A B 30 degrees, & let the side B E be required. In which case having let fall the perpendicular B C, and found the angle c B e. Say,

As the Co-sine of c C e, is to the Co-sine of a B c;
So is the Tangent of A B, To the Tangent of B E. Therefore,

Set 36 degr. 46 min. the Co-sine of the angle c B e on the first, to the Co-sine of the angle a B c; and then against 30 degrees, the tangent of the side given, is the tangent 18 deg. 47 min. the side B E, which was required.

PROBLEM. XXIV.

Two angles, with the sides lying betwixt them being given, to find the third angle.

LEt the angle A 23 deg.30 min. and the angle B 122 degr.36 min. with the side A B

 30 de-

30 degrees be given, and the third angle at E, required.

Having let fall the Perpendicular, and found the angles a B c, and c B e. Then say,

As the Sine of a B c, is to the Sine of c B e,
So is the Co-sine of A, the angle given, to
the Co-sine of E, the angle sought,
Therefore,

Set 69 deg. 22 min. the Sine of a B c on the first, to 53 degr. 14 min. the Sine c B e on the second; and then against the Co-sine of A 66 deg. 30 min. on the first, is 51 degr. 45 min. the Co-sine of the angle E. Wherefore E is 38 deg. 15 min.

PROBLEM. XXV.

Two angles, and a side opposite to one of them being given; to find the side adjacent to both the angles,

LEt the angles A 23 degr. 30 min. and E 38 15 min. with the side B A 30 degrees, being opposite to the angle E be given, and the side A E required.

Having let fall the Perpendicular, and together with it found A C, part of A E.

Say then,

As the tangent of E, is to the tangent of A.
So is the sine of A C, to the sine of C E.

There-

Therefore,

Set 38 deg. 15 min.the tangent of E on the first, to 23 deg. 30 min. the Tangent of A on the second ; and then against 27 deg. 54 min. the sine of the side of A C on the first, is 14 deg.57 min. on the second, which is the sine of C E.This 14 deg.57 min.added to 27 deg. 54 min.the other part A C afore found,makes 42 deg.51 min.for the whole side A E,which was sought.

PROBLEM. XXVI.

Two angles, and a side opposite to one of them being known ; to find the third angle.

LEt the angles given be A 23 deg. 30 min. and E 38 deg.15 min.and let the side AB being opposite to the angle E,be 30 degr.and let the third angle a B e be required.

As in the former Problems, so also in this ; Let fall the Perpendicular B C,and by it gain the angle a B c, which being had,to gain the Remainder of the angle a B e. Say,

As the Co-sine of the angle A,is to the Co-sine of the angle E ;

So is the sine of a B c, to the sine of c B e.

Therefore,

Set 66 deg. 30 min, the Co-sine of the angle A on the first,to 51 deg. 45 min. the Co-

ſine of the angle E on the ſecond; and then againſt 69 degr. 22 min. the ſine of a B c on the firſt, is 53 degr. 14 min. the ſine of c B e. Theſe two angles added together, make 122 degr. 36 min. the angle A B B, which was required.

PROBLEM. XXVII.

The three ſides being given, to find any one of the angles.

LEt the three ſides be A B 30 deg. A E 42 deg. 51 min. and B E 18 deg. 47 min. and let the angle B be ſought.

To reſolve this Problem: Firſt, Add all the three ſides together into one ſum, of which ſum take the half, and then from that half take the ſide oppoſite to the angle ſought, and reſerve the difference. As for Example.

The three ſides given, are	A B	30 d. 00 m.
	A E	42 d. 51 m.
	B E	18 d. 47 m.
The ſum of the three ſide		91 d. 38 m.
The half of that ſum		45 d. 49 m.
The ſide A E, oppoſite to the required angle B, ſubſtracted		42 d. 51 m.
And the Differ. to be reſerved is		2 d. 58 m.

This

This done, to proceed to find the angle ſought. Say,

1 As the Radius,is to the Sine of one of the ſides including the angle ſought; So is the Sine of the other ſide, including the ſame angle, to a fourth Sine.

2 As that fourth Sine, is to the Sine of the half ſum; So is the Sine of the reſerved difference, to a ſeventh Sine.

Therefore,

1 Set the Radius on the firſt,to 30 deg.the Sine of one of the ſides given, including the angle ſought;and then againſt 18 deg.47 min. the Sine of the other including ſide,is 9 degr. 16 min. for a fourth Sine.

2 Set this fourth Sine 9 deg.17 min.on the firſt, to 45 deg. 49 min.the Sine of the half ſum on the ſecond; and then againſt 2 degr. 58 min. the Sine of the reſerved difference,is 13 deg, 20 min. for the ſeventh Sine.

This being done (by the help of a pair of Compaſſes, or otherwiſe) divide the diſtance betwixt this point of 13 deg. 20 min. and the Radius into two equal parts, and the middle point is at 28 deg. 42 min. whoſe Complement 61 degr. 18 min. doubled, makes 122 degr. 36 min. the angle a B e, which was ſought.

PRO-

PROBLEM. XXVIII.

The three angles being onely known, to find any of the sides.

TO resolve this Problem, the angles are to be turned into sides, and the sides into angles, (otherwise it is unresolveable) and it is thus done: Instead of the greatest angle, take its Complement to 180 degrees, and then the angles convert themselves into sides, and the sides into angles, and then the resolution is just the same as in the last Problem.

CHAP.

CHAP. XII

The Use of the Instrument in Navigation.

THis Instrument, with these Double Scales inscribed thereon, is of most excellent use in Navigation, as I shall shew in part, and leave the rest to the Ingenious to find out of themselves. And first, by the Meridian Line, and Line of equal parts joyned together upon the Instrument, you may do all things that may be done by the Table of Meridional Degrees, set forth by Mr. *Wright* Mr. *Gunter*, Mr. *Wingate*, and others treating of Navigation.

PROBLEM. I.

Two places being propounded, the one under the Equinoctial, and the other without; to find their Meridional Difference.

LOok the Latitude of that place situate without the Equinoctial, upon the Meridian line, and right against it, on the Line of equal parts, is the Meridional Difference of those two places.

Example.

Example. Let the enterance of the River of the Amazons, under the Equinoctial, be one place propounded, and the Lizard in the Latitude of 50 degrees be the other place, between which the Meridional Difference is desired.

Look 50 degrees, the Latitude of the Lizard on the Meridian Line, & right against it on the Line of equal parts, is 57 degrees, 90 centesimal minutes. which is 57 degrees, and 9 tenth parts of a degree, or 57 degrees, 54 sexaginary minutes. So much is the Meridional Difference of those two places.

PROBLEM. II.

Two places having both Northerly, or both Southerly Latitude; to find their Meridonal Difference.

SUbstract the degrees and minutes which you find on the Line of equal parts against the lesser Latitude, from the degrees and minutes found on the same Line of equal parts against the greater Latitude, and the Remainder is the Meridional Difference of those two places.

Example. Let St. *Christophers* and the *Lizard* be two places, between which you would find the Meridional Difference; the Latitude of

Set.

St. *Christophers* is known to be 15 degrees 30 minutes North, to which answereth on the Line of equal parts 15 deg. 69 centesimal minutes: the Latitude of the *Lizard* is also known to be 50 degrees North. To which on the Line of equal parts answereth 57 degr. 90 centesms. Now take 15 degr. 69 cent. the lesser number of degrees found on the Line of equal parts, out of 57 deg. 90 cent. the greater number of degrees found on the Line of equall parts, and the Remainder is 42 degr. 21 cent. or 42 deg. 12 min. of the sexaginary division. So much is the Meridional Difference desired.

PROBLEM. III.

Two places being situate, the one Southerly, and the other Northerly; to find the Meridional Difference.

TAke the degrees and parts found on the Line of equal parts, against the two Latitudes proposed, sought in the Meridian Line, and add them both together, and the sum of that addition is the Meridional Difference.

Example. Let the two places proposed be the *Cape of Good Hope*, in the Latitude of 36 deg. 30 min. South, and *Japan* in the *East Indies*, whose Latitude is 30 degrees North. Now on the Meridian Line, look 36 degr, 30. min. and against

against it on the Line of equal parts, is 39 deg. 15 min. and against the 30 degrees is 31 deg. 28 min. These two sums 39, 15, and 31, 28 being added together, make 70 deg. 43 min. So much is the Meridional Difference required.

PROBLEM IV.

The Latitude of two places, and their Difference of Longitude being known; to find the Rumb leading from the one to the other.

LEt the two places proposed be the *Lizard* and St. *Christophers*; the Latitude of the *Lizard* 50 degrees, and of St. *Christophers* 15 deg. 30 min. and their Difference of Longitude 68 deg, 30 min. And let the Rumb passing from the *Lizard* to St. *Christophers* be required.

First, by the second Problem, seek the Meridional Difference between the two places, which you find to be 42 deg. 12 min. by that second Problem. Then,

Upon the Line of Numbers, Set 68 degree 30 min. the Difference of Longitude on the first, to 42 deg. 12 min. the Meridional Difference on the second; and then upon the Lines of Tangents against the Radius on the first, is the Tangents 58 deg. 21 min. on the second. So much lieth the Rumb from the Meridian, which is on the fifth Rumb from the Meridian

West-

Westwards, and two degrees 6 minutes, over and above that fifth Rumb.

And if you be to sail from the *Lizard* to the *Bermudas Ilands*, in the Latitude of 32 degr. 25 min. whose Difference of Longitude is known to be Westwards 70 degrees; and you would know on what point of the Compass you must steer your course thither.

Here first by the second Problem, seek the Meridional Difference, and find it 23 deg. 36 min. And then,

Set 70, the Difference of Longitude on the first, to 23 deg. 36 min. the Meridional Difference on the second; and then against the Radius on the first; is the Tangent 71 deg. 21 min. on the second; that is, on the point 71 deg. 21 min. from the Meridian, or South point, which is on the sixth Rumb, and 3 deg. 51 min. over. And because the *Bermudas* lye Westwards from the Meridian of the *Lizard*; therefore the Rumb is the West Southwest point, and 3 deg. 51 min. over.

Here is to be noted, that every Rumb from the Meridian containeth 11 deg. 15 min. And therefore the first Rumb makes an angle with the Meridian of 11 degr. 15 min. the second Rumb an angle of 22 deg. 30 min. and so of the rest, as in the little Table following appeareth, wherein you see that the sixth Rumb makes

makes an angle of 67 degr. 30 min. which taken from 71 deg. 21 min. in this last Example found, there remained 3 deg. 21 min. over the sixth Rumb.

Rumbs	1	11 deg. 15 min.
	2	22 deg. 30 min.
	3	33 deg. 45 min.
	4	45 deg. 00 min.
	5	56 deg. 15 min.
	6	67 deg. 30 min.
	7	78 deg. 45 min.
	8	90 deg. 00 min.

PROBLEM. V.

The Latitudes of two places being given with the Rumb; to find the distance upon the Rumb.

LEt the place from whence you sail be in the Latitude of 50 degrees, and the Latitude of a place to which you are come, be 52 deg. 30 min. So that the Difference of Latitude is 2 deg. 30 min. find also you, and that you have sailed on the first Rumb, from the Meridian Northerly, that is, have made an angle with the Meridian of 56 deg. 15 min. The Complement of the fifth Rumb to eight is 3 which is 33 deg. 45 min. and you would know your distance sailed upon that Rumb.

Set

Set 33 degr. 45 min. the Co-ſine of the Rumb on the firſt, to the Radius on the ſecond & then on the Line of Numbers, againſt 2,50 the Difference of Latitude on the firſt, is 4,50 on the ſecond, that is to ſay, 4 degrees 50 centeſmes, or 4 deg. 30 min. So much is the diſtance ſailed upon that courſe, in degrees and minutes.

Again. Let the *Lizard*, lying in 50 degrees of North Latitude, be the place from whence you are to go; and let the other place that you are to go unto be *St. Chriſtophers*, in the Latitude of 15 deg. 30 min. North. And the Rumb leading from one to the other, bearing from the Meridian of the *Lizard* 58 degr. 21 min. which is ſomething more than the fifth Rumb. Now by theſe things known, you would know the diſtance upon the Rumb between thoſe two places.

Here you muſt firſt of all ſubſtract 15 degr. 30 min. the leſſer Latitude out of 50 degrees, the greater Latitude, and the Remainder 34 deg. 30 min. is the true Difference of Latitude: and then, Set 31 degr. 39 min. the Co-ſine of the Rumb on the firſt, to the Radius on the ſecond; and then on the Line of Numbers, againſt 34,30 repreſenting 34 deg. 30 min. the Difference of Latitude on that firſt, is 65, 46 on the ſecond; that is 65 deg. 46 min. So much

in

in degrees & minutes, is the distance upon the Rumb between the *Lizard* and St. *Christophers*.

PROBLEM. VI.

The Latitudes of two places, and their distance being known, to find the Rumb leading from one to another.

LEt the two places propounded be those mentioned in the last Problem, whose Latitudes were 50 degrees, and 52 deg. 30 min. and their distance known 4 deg. 30 min. & the Rumb you know not, but desire to know it.

Upon the Lines of Numbers, Set 4,30 representing 4 deg. 30 minutes, the distance known, on the first, to 2,30 representing 2 degrees 30 minutes, the Difference of Latitude on the second; and then upon the Lines of Sines, against the Radius on the first, is the Sine 33 degr, 45 min. on the second, whose Co-sine is 56 deg. 15 min. So much is the distance that the course lieth from the Meridian, which is upon the fifth Rumb.

Or let the *Lizard*, in the Latitude of 50 deg. and St. *Christophers* in the Latitud 55 deg 30 min. be the two places proposed, whose Difference of Latitude is 34 deg. 46 min. and their distance known 65 deg. 46 min. and the Rumb that the course lieth upon, is desired.

Upon

Upon the Line of Numbers, 65,46 the di-ſtance known on the firſt, to 34,46 the Difference of Latitude on the ſecond; and then on the Lines of Sines, againſt the Radius on the firſt, is 58 degr. 21 min. on the ſecond, So much is the diſtance of the Rumb from the Meridian of the *Lizard*, on which the Courſe lieth.

PROBLEM. VII.

The Latitude of the place from whence you go, the Rumb you go upon, and the diſtance gone, being given; to find the Difference of Latitude, and thereby the Latitude of the place you are in.

LEt the place you go from, be in the Latitude of 50 degrees, the Rumb you have gone upon, the fifth from the Meridian, and the diſtance gone, 4 deg. 30 min. And by theſe you deſire to know the Difference of Latitude, with the latitude of the place you are in.

Set the Radius on the firſt, to 33 degr. 45 min. the Co-ſine of the Rumb on the ſecond; and then upon the Lines of Numbers; againſt 4, 30 repreſenting 4 deg. 30 min. the diſtance gone on the firſt, is 2,30 on the ſecond, that is 2 deg. 30 min. So much is the Difference of Latitude. This 2 deg. 30 min. added to the Latitude of the place you came from, (becauſe

the Course was Northerly) makes 52 deg.30 min.for the Latitude of the place you are in.

Example. Suppose you were at St. *Christophers*, in the Latitude of 15 degr.30 min.and from thence had sailed Northwards near upon the fifth Rumb from the Meridian; or on the true point of 58 deg. 21 min. from the Meridian,and at length came to a place,where you found that you had salid 65 deg.46 min.from St. *Christophers*,and now do desire to know in what Latitude you are.

Set the Radius on the first,to 31 degr. 39 min.the Co-sine of the Rumb on the second; and then upon the Line of Numbers, against 65,46 representing 65 deg.46 min.the distance gone on the first,is 34,30 on the second,signifying 34 deg.30 min. So much doth the Latitude you are in, differ from that you came from,and because the Course was Northerly, the Latitude is increased.Therefore this Difference found, 34 deg.30 min. is to be added to the known Latitude,15 deg. 30 min. and they both make 50 degrees just:Therefore the Latitude of the place you are in,is 50 degrees of North Latitude.

If the place you went from had been the *Lizard*,in 50 degrees of Latitude,and you sail from thence more Southwards upon the point 58 degr. 21 min. from the Meridian Westwards,

wards, and on this Courſe have ſailed 65 deg. 46 min. and ſo found, that you have altered your Latitude 34 degr. 30 min. and are come to a place of unknown Latitude. In this caſe, becauſe the Courſe is Southerly (the Latitude of the place you are in, is leſs than that you came from) you muſt take the Difference of Latitude found 34 degr. 30 min. from 50 deg. the Latitude known, the Remainder is 15 deg. 30 min. The Latitude of the place you are in.

PROBLEM. VIII.

The Latitude of the place you are in, and the Latitude of the place you went from, with the Rumb being given; to find the Difference of Longitude.

LEt the two places be, one the *Lizard* in the Latitude of 50 degrees, from whence you go, and the other place St. *Chriſtophers*, in the Latitude of 15 deg. 30 min. and the Rumb 58 deg. 21 min. from the Meridian, and the thing deſired is the Difference of Longitude.

Firſt, by the ſecond Problem, find out the Meridonal Difference, 42 deg. 12 min. which had; Set the Tangent of the Rumb, 58 degr. 21 min. on the firſt, to the Radius on the ſecond; and then upon the Line of Numbers, againſt 42 deg. 12 min. on the firſt, is 68 deg.

30 min. on the ſecond. Wherefore 68 deg. 30 min. is the Difference of Longitude betwixt your two places, the *Lizard* and St. *Chriſtophers*.

And if the place you came from, be in the Latitude of 50 degrees, and of that you are in, be 25 deg. 30 min. and the Rumb you have come upon, be the fifth from the Meridian, and you deſire the Difference of Longitude. Then,

Set 56 deg. 15 min. the Tangent of the fifth Rumb on the firſt, to the Radius on the ſecond, and then upon the Line of Numbers, againſt 2 deg. 30 min. the Meridional Difference of Latitudes on the firſt, is 3 deg. 45 min. on the ſecond. So much is the Difference of Longitude deſired according to the projection of the common Sea-Chart.

PROBLEM. IX.

In any Parallel of Latitude, to find out how many Leagues anſwer to one degree of Longitude in that Parallel.

THis Problem is grounded upon this Analogie.

As the Radius, is to the Co-ſine of the Latitude; So is the number of leagues, in one Equinoctial degree, to the number of leagues anſwering to one degree in that Latitude.

Example.

Example. In the Latitude of 18 deg. 12 min. I demand how many leagues ſailing a long in that Parallel, will alter the Longitude one degree?

For anſwer, to my deſire, I ſet the Radius on the firſt, to 71 deg. 48 min. the Co-ſine of the Latitude on the ſecond; and then on the Line of Numbers, againſt 20 on the firſt, the number of leagues in our Equinoctial degree, I ſee 19 on the ſecond: And therefore every 19 leagues ſailing along it that Parallel, altereth the Longitude one degree: And on the contrary, for every degree that you alter your Longitude, you ſail 19 leagues in that Parallel.

2 In the Latitude of 51 degrees 32 minutes, it is demanded, How many leagues in that Parallel, do anſwer to one degree of Longitude?

Set the Radius on the firſt, to 38 degr. 28 min. the Co-ſine of the Latitude on the ſecond; and then on the Line of Numbers, againſt 20 on the firſt, is 12 and 4 tenths on the ſecond. So many leagues ſailing in that Parallel of 15 degr. 30 min. altereth the Longitude one degree.

If you would know how many miles alter one degrees of Longitude in any Parallel.

Then,

Set the Radius on the firſt, to 38 degr.

 28 min.

28 min. the Co-ſine of the latitude on the ſecond ; and then on the lines of Numbers, againſt 60 on the firſt;is 37 and about on third which is 37 miles,and one third of a mile, to make one degree of longitude in that Parallel of latitude. And contrariwiſe,if you find you have altered your longitude one degree,you are then removed 37 miles, and about one third of a mile.

PROBLEM. X.

To find how many miles anſwer to many degrees of Longitude in any parallel.

SUppoſe you ſhould ſail along in the Parallel of 50 degrees, until you have altered your longitude 35 degrees, and then would know how many miles you have ſailed.

Firſt, reduce 35 Equinoctial degrees into minutes,by multiplying them by 60,and they make 210,minutes. Then.

Set the Radius on the firſt, to 40 degr. the Co-ſine of the latitude on the ſecond ; and then againſt 2100,the Difference of longitude in minutes,upon the firſt on the line of Numbers, is 1350 on the ſecond. So many miles anſwer to 35 degrees,in that Parallel.

But if you would know how many leagues you have ſailed,in altering your longitude 35 degrees,

degrees, then reduce the 35 degr. into leagues by multiplying them by 20, & they make 700. Now, Set the Radius to 40 degrees, as afore, & then right againſt 700, in the line of Numbers on the firſt, is 450 on the ſecond. So many leagues you have ſalied.

PROBLEM. XI.

Upon any Rumb propoſed, to find how many leagues do anſwer to one degree of latitude in the Meridian, or of any great circle.

This Problem is reſolved by this Analogie.

As the Co-ſine of the Rumb from the Meridian, is to the Radius;
So is 20 leagues, the meaſure of one degree in any great circle, To the leagues that anſwer to one degree upon that Rumb.

Example. Suppoſe you ſail upon the fourth Rumb from the Meridian, which is the point of Northeaſt, or Southweſt; or elſe the point Southeaſt, or Southweſt, and deſire to know upon that Rumb, how many leagues do anſwer to one degree of the Meridian, or alter the latitude one degree.

Set 45 degrees, the Co-ſine of the Rumb on the firſt, to the Radius on the ſecond; and then on the line of Numbers, againſt 20, the

number of leagues in a degree of a great circle on the first, is 28 and almost an half. Therefore 28 leagues and an half, make one degree, or alter the Latitude one degree, in sailing upon that Rumb.

If you desire to know how many miles sailing on any Rumb, alter the Latitude one degree, as here in this Example of the fourth Rumb; then set 45 degrees the Co-sine of the Rumb on the first, to the Raduis on the second; and then on the lines of Numbers, against 60 on the first, is 85 & something above one third. So many miles, on that fourth Rumb, altereth one degree of Latitude.

I am now in the middest of the Sea, where if I should sail through all particulars; that my Instrument is capable of, I should with my travel fill a great Volume, I will therefore leave off wading any further in this Subject, and leave the rest to the ingenuous Practioners in Navigation, to whom I wish prosperity in all their honest and laudable undertakings.

CHAP.

CHAP. XIII.

The Use of the double Scales of Sines and Tangents on the Instruments, in Dialiing.

PROBLEM. I.

Two find the distance of the hours from the Line of twelve a clock, Horizontal Dials, made for an oblique Sphere.

LEt an Horizontal Dial be propounded, to be drawn for the elevation of the Pole 51 deg.30 min. For making whereof the Analogie standeth thus:

As the Radius, is to the Sine of the Elevation:

So is the Tangent of the hours in a right Sphere from 12, To the Tangent of the same hours from the line of 12, in the oblique Sphere propounded. Therefore,

Set the Radius on the first, to the Sine of the Elevation given. *viz.* to 51 deg.30 min. on the second; and then the Instrument unremoved, against 15 deg. the Tangent of an Equinoctial hour on the first, is 11 degr. 51 min. the Tangent of on hours distance from the line of 12 a clock

a clock in the oblique Sphere of 51 degr. 30 min. and against 30 degrees on the first, being the distance of two Equinoctial hours, is 24 deg. 19 min. on the second, for the distance of two hours from the line of 12, in that given latitude. And likewise, against the Tangent of 45 degrees on the first, the distance of three Equinoctial hours, in a right Sphere on that first, is the Tangent of 28 degr. 3 min. on the second, for the distance of the hours of 3 and 9 a clock, from the hour line of 12, in that given latitude.

But now for the fourth and fifth hours, because the Tangents of those hours be above 45 degrees, you must work backwards in this manner: The Instrument not stirred, look 60 degrees, the equall distance of the fourth hour in a right Sphere on the second; and then against that Tangent of 60 degrees on that second, is the Tangent 53 degr. 35 min. on the first: for the hours of four and eight; and also against the Tangent of 75 degrees, the fifth equal hour on that second, is the Tangent 71 degr. 6 min. on the first, for the hours of 5 in the fore-noon, and 7 after-noon: As for the hours of 6 and 6, they are at just 90 deg. from the hour-line of 12 a clock, and so for any other latitude: for the hours of 5 and 4 in the morning, they are equally distant from the hour

hour of 6, as in 7 and 8; and ſo in the afternoon, the hours of 7 and 8 are equally diſtant from 6, as is 5 and 4. By the ſame rule ſhall you find half hours and quarters, as when you would have the true diſtance of one hour and an half from the noon-line. then work by the Tangent of 22 degr. 30 min. and in ſo doing, you ſhall have 17 degr. 38 min. to be the diſtance of one hour & an half from the noon-line, in the Latitude of 51 deg. 30 min. and ſo for any other.

PROBLEM. II.

A Dial being made, and the Elevation for which it was made not being known; to find for what Latitude it is made.

FIrſt of all, get the diſtance between the hours of 12 and 1, which had, Set the Tangent of 15 deg. on the firſt, to the Tangent of that diſtance on the ſecond; and then againſt the Radius on the firſt, is the Sine of the Elevation ſought for on the ſecond.

Example. There is an old Dial, which doth appear to be a good one, and I deſire to know for what Latitude it was made, as alſo whether it be true made, or not; which to do, I firſt ſeek the diſtance betwixt 12 and 1, and find it 11 degr. 51 min. Therefore I ſet the Tangent of

of 15 degrees on the first, to the Tangent of that distance, 11 deg. 51 min. on the second; and then against the Radius on the first, is the Sine 51 degr. 30 min. on the second. Whereupon I conclude. that the Dial was made for the Elevation of 51 degr. 30 min. Thus may you examine any Dial, whether it be truely made, or not.

PROBLEM. III.

To find the distances of the hour-lines, from the line of 12 *a clock in a direct South Dial. for any Eelvation propounded.*

IN the Latitude of 51 degr. 30 min. a Dial is to be made, wherein to find the distance of the hour-lines from the line of 12 a clock.

Say as in the first Problem,

As the Radius, To the Co-sine of the Poles Elevation;

So is the Tangent of any hour given, To the Tangent of the hour line from the Meridian, Therefore,

Set the Radius on the first, to 38 deg. 30 min. the Co-sine of the Latitude on the second; and then against the Tangent of 15 deg. on the first, is the Tangent of 9 degr. 28 min. on the second, for the hours of 1 and 11; and against 30 degr. on the first, is the Tangent 19 deg.

19 deg. 46 min on the ſecond,the diſtance of the hours of 2 and 10, from the line of 12. And againſt the Tangent 45 on the firſt,is the Tangent 31 deg.54 min.on the ſecond,for the diſtance of the hour-lines of 9 and 3,from the line of 12. And now backwards, againſt the Tangent of 60 deg.on the ſecond, is 47 degr. 10 min.on the firſt,the Tangent of the diſtances of the hour-lines of 4 and 8, from the line of 12. And laſtly, againſt 75 degr. on the ſecond,is 66 deg.43 min. on the firſt, the Tangent of the diſtance of the hour-lines of 7 and 5,from the line of 12. For the hours of 6 and 6, they make right angles with the Meridian.

PROBLEM. IV.

In a vertical Dial inclining, having the Elevation of the Pole above the Plane; to find the diſtance of the hour lines from the hour-line of 12 a clock.

LEt ſuch a Plane be propounded, whoſe North part is elevated above the Horizon 16 deg. 30 min.which taken from the Elevation of the place 51 degr.30 min. leaveth 35 degrees, for the Elevation of the Pole above the Dials Plane: Wherefore to find the diſtance of the hour-lines in ſuch a Dial from the Meridian,or hour-line of 12. Say,

As

As the Radius, Is to the Sine of the Elevation above the Plane;
So is the Tangent of any Equinoctial hour, To the distance of the same hour-line from the Meridian, Therefore,

Set the Radius on the first, to 35 degrees, the Sine of the Poles Elevation above the Dials Plane; and then against the Tangent of 15 degrees, which is the Tangent of one Equinoctial hour on the first, is 8 degr. 45 min. on the second, the Tangent of the distance of the hours of 1 and 11: from the hour-line of 12: and against 30 deg. on the first, is 18 degr. 19 min on the second, for the hours of 2 and 10. And for the rest of the hours, you shall have them as you had those in the former Dials.

PROBLEM. V.

In any erect declining Dial, to find the distance of the Styll from the Substyl; and of the Substyll from the Meridian.

IN the Latitude of 52 degr. I would make a Dial to a wall, declining from the true South point 43 deg. wherein first to find the distance of the Styll from the Substyll, the work is thus:

As the Radius, To 45 degr. the Co-sine of the declination of the Dials Plane from the true South point.

So

So is 38 degr.the Co-ſine of the Latitude,
To 25 degr,48 min. the diſtance of the Styll,from the Subſtyll. Therefore,

Set the Radius on the firſt, to 45 degr.the Co-ſine of the Declination on the ſecond; & then againſt 38 degr. the Co ſine of the Latitude on the firſt, is 25 degr. 48 min.on the ſecond.So much is the diſtance of the Styll from the Subſtyl,or height of the Styll.

Or ſet the Radius to 38 deg.& then againſt 45 deg. is 25 deg. 48 min.

And then for the diſtance of the Subſtyll from the Meridian,this is the Rule.

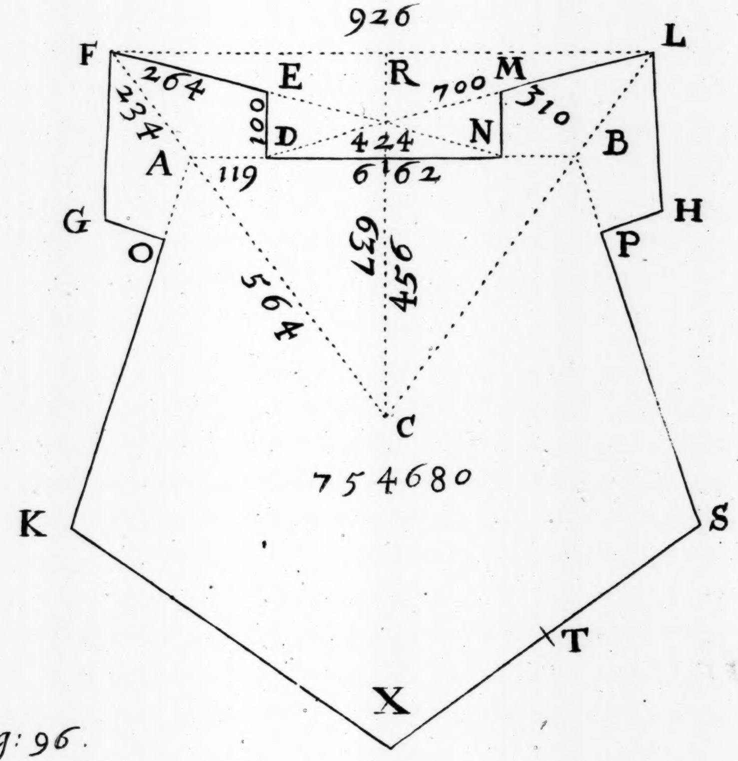
Take 64 degr. 12 min.the Co-ſine of that 25 degr. 48 min. the diſtance found, and 52 degr.the Latitude of the place,and count the greater of them two Sines for the firſt term in the rule of Proportion, and the leſſer of them for the ſecond term,and the Radius for the third term. And then,

Set the Sine 64 degr. 12 min. on the firſt, (which is theCo-ſine of that ſine afore found) to the Radius on the ſecond;and then againſt 52 degrees, the Latitude of the place on the firſt, is 61 degr. 5 min.on the ſecond, whoſe Complement is 28 deg. 55 min. So much is the diſtance of the Subſtyl from the Meridian, in ſuch a declining Dial. And ſo of any other.

But

But I see by my Dial, that the Sun is declined from the Meridian far into the west, casting his sh[illegible] at half an hour past six a clock after noo[illegible]nd Saturday night, *August* the first 1657, time to leave work. And for as much as my occasions call me another way for the next week, and for many weeks after, I must leave off proceeding any further in this Subject of Dialling.

FINIS.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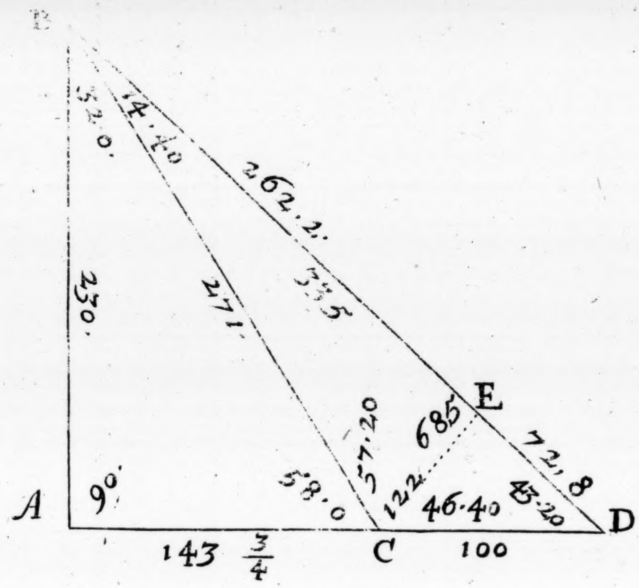
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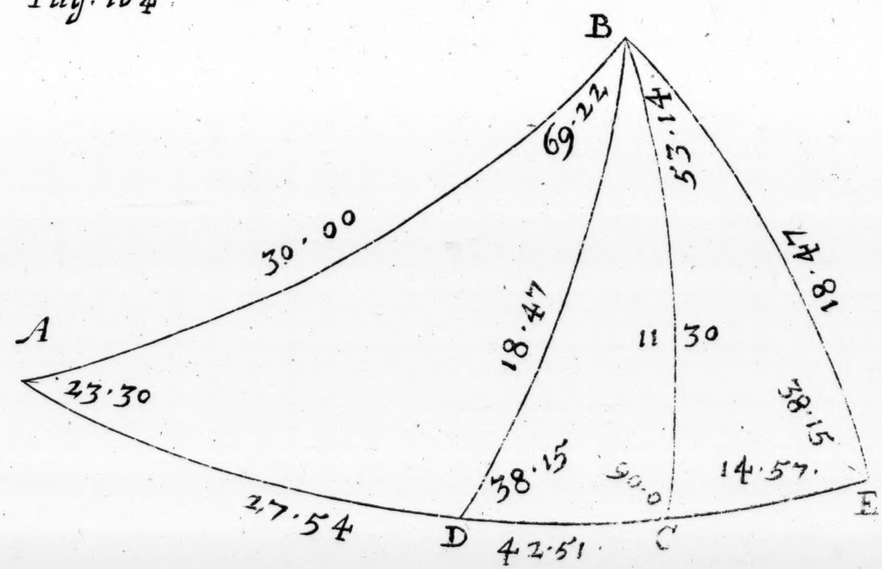
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